DRAGON

WHAT CONCRETE WILL DO-

Compliments of

THE LAWRENCE CEMENT COMPANY

ONE BROADWAY, NEW YORK

DRAGON PORTLAND CEMENT

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BIRDSEYE VIEW OF THE LAWRENCE PORTLAND CEMENT CO. WORKS

DRAGON PORTLAND CEMENT

IN USE TWENTY-ONE YEARS

SALES OFFICES

THE LAWRENCE CEMENT CO.

Nº 1 BROADWAY · NEW YORK

AND

LAWRENCE PORTLAND CEMENT Cº

HARRISON BUILDING, PHILADELPHIA

1910 EDITION

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FOREWORD

TO the house owner, suburbanite, gardener, and farmer, concrete has shown itself to be of inestimable value. The facility with which cement, one of its chief ingredients, can be obtained, the almost universal distribution of sand and gravel, and the ease with which these materials can be combined into concrete give it a unique place as a structural material. It has entered the field at a time when lumber is advancing in price at a rate which will shortly make it prohibitive for the cheaper varieties of structures. Concrete possesses so many inherent virtues with regard to sanitary value, durability, versatility of application, moderate cost, and wide possibility of giving effects of high artistic value, that it can justly claim attention on its own behalf even were the conservation of the timber resources of the Nation not a burning question of the day.

Almost every part of every construction on the farm and around the country house can be and has been made of concrete either in mass form or when reinforced. Foundations and superstructures are easily made of this material. Dwellings, stables, barns, silos, green-houses and other elaborate buildings are now erected of reinforced concrete. An ordinary carpenter can make the necessary wooden forms for these as well as for simpler structures like ice-houses, piggeries, troughs, tanks and cisterns where plain concrete is used. Even fence posts and rails, barn floors and feeding floors are being constructed of concrete instead of wood.

Concrete is indispensable in dairy farming since boards of health are demanding better sanitary conditions in dairies, which can be secured most economically only where concrete is used for the construction of cow stables. Similarly, poultry houses and yards can be maintained in a high sanitary condition where concrete is employed and the latest developments even provide cement hens' nests and runways.

There is no stronger and more enduring concrete for any purposes to which it may be applied, than that made with Dragon Portland Cement, manufactured by the Lawrence Portland Cement Co. The fact that this Dragon brand has been on the market for TWENTY YEARS or more testifies to its unexcelled characteristics of uniformity, high quality and great durability.

In the following pages will be mentioned some of the many uses for which concrete is suitable, together with clear and explicit directions how to prepare it out of Dragon Portland Cement.

RELATIVE COST OF CONCRETE BUILDINGS.

WHENEVER a farmer or other prospective builder has upon his property gravel and sand which is available for concrete work, one of the several items which enter into its cost can be ignored, except for the time occupied in taking it from the pit, and hauling it to the place of construction. On the other hand where it is necessary to purchase broken stone, or gravel, the cost of the concrete will vary in price. The main item in concrete work is simply the cost of the forms.

An inferior grade of lumber can generally be used in making forms for concrete, which would seldom be allowed in the erection of frame buildings except for the poorer classes. The only other main item is that of labor. When men are permanently employed by the month, or where the owner can himself supervise the work, and lend a hand, this item can be greatly reduced. Some of the illustrations shown in this book are of work constructed by a single man employing his odd moments, and making forms out of scrap pieces of lumber. In such instances the costs are reduced to a minimum, and no other mode of construction can compare with concrete in cheapness.

SUPERIORITY OF CONCRETE.—Taking all these things into consideration it will usually be found that for side-walks, cellar and stable floors, foundations, retaining walls, dams, culverts, fence posts, water tanks, troughs, steps, and similar structures, concrete is somewhat more expensive than wood. The life of the concrete, however, is so much longer, that when the matter of replacement is considered, concrete is found to be far superior. For small buildings like chicken houses, machinery sheds, ice houses, piggeries, and small stables, all of the poorer grades of wooden construction may still be slightly cheaper than concrete, but when permanency and fire proof character are considered concrete will be found preferable.

CONCRETE CHEAPEST.—Finally, for larger stables, houses, and the more extensive farm and suburban structures, which are built under the direction of experienced contractors, and where conditions are favorable, concrete is almost invariably cheaper than either timber, or brick, or brick and timber. Many of the structures illustrated in this book were originally designed to be built in wood, but it was found after investigation that concrete could be employed for practically the same financial outlay. A change was therefore made to that material. Under many exceptional circumstances concrete will cost only a little more than two-thirds as much as timber construction. Prospective builders in ascertaining the relative costs of the two materials, should consider the fire proof quality of concrete, its freedom from infection by decay, and its unnecessary maintenance costs.

WHAT CONCRETE IS*

CONCRETE is made by mixing together in proper proportions, cement, sand, and stone, or gravel. Various proportions of each are used, depending upon the purpose to which the concrete is put. The ideal mixture is where all the spaces (called voids) between the stone or gravel are filled with sand and all the spaces between the different particles of sand are filled with cement.

TABLE I.

Showing the Quantities of Materials and the Resulting Amount of Concrete for Two-Bag Batch.

Kind of Concrete Mixture.	TWO-BAG BATCH									
	Proportions by parts			Materials			Resulting Quantity of Concrete	Size of Measuring Boxes Inside Measurements		Water in Gallons for Medium Wet Mixture
	Cement	Sand	Stone or Gravel	Cement	Sand	Stone or Gravel		Sand	Stone or Gravel	
				Bags	Cu. ft.	Cu. ft.	Cu. ft.			Gals.
1:2 :4 Concrete	1	2	4	2	3¾	7½	8½	2'x2' x11½"	2'x4'x11½"	10
1:2½:5 Concrete	1	2½	5	2	4¾	9½	10¼	2'x2½'x11½"	2'x5'x11½"	12
1:3 :6 Concrete	1	3	6	2	5¾	11½	12	2'x3' x11½"	3'x4'x11½"	13
1:4 :8 Concrete	1	4	8	2	7½	15	15	2'x4' x11½"	4'x4'x11½"	15

Note: A barrel of Dragon Cement is always equal to four bags.

It will be noticed that these different concrete mixtures show the resulting bulk (quantity) is only slightly greater in size than the gravel alone, which is on account of the voids in the gravel being filled with sand and cement.

* This chapter is taken in part from Bulletin Twenty of the Association of American Portland Cement Manufacturers, entitled "The Mixing and Placing of Concrete by Hand." This bulletin will be mailed to any interested farmer or house owner upon application to the Secretary of the Association, Philadelphia, Pa.

EXPLANATION OF PROPORTIONS. Table No. 1 shows the amount of cement, sand and stone used in the various grades of concrete work. All materials are measured by volume. A 1:2:4 mixture means one part cement, twice as much sand, and four times as much stone or gravel, making the whole mixture consist of seven parts. A 1:3:6 mixture means one part cement, three times as much sand, and six times as much stone or gravel, making the whole mixture consist of ten parts.

EXAMPLE: Suppose a 1:2:4 concrete mixture is selected. Then, under the column heading "Kind of Concrete Mixture" (Table 1, p. 7), take the line marked 1:2:4 Concrete, and running to the right across the page, all the quantities of materials can be found. Under the "Proportions by Parts" it can be seen that there is one part cement, two parts sand and four parts stone or gravel, and this is the mixture specified. Then, running further across the page are found the quantities of cement, sand, and stone or gravel under their respective headings, to be mixed together in a two-bag batch. There are two bags of Portland cement, 3¾ cubic feet of sand, and 7½ cubic feet of stone or gravel. In the next column the quantity of concrete resulting from the above mixture is found to be 8½ cubic feet. Under "Size of Measuring Boxes" it is found that the sand should just fill a box 2 feet long by 2 feet wide by 11½ inches deep, while the stone or gravel should similarly fill a box 4 feet long by 2 feet wide by 11½ inches deep. The next column gives 10 gallons as the amount of water to be used for a trial in mixing the first batch.

Sand and stone (or gravel) are to be measured loose in the boxes. Do not pack them.

TWO-BAG BATCH. A two-bag batch of concrete requires two bags of cement, the sand and stone or gravel being proportioned accordingly as shown. For a four-bag batch, multiply the amount of stone and gravel by two, double the cubic contents of the measuring boxes, and use four bags of cement, and twice as much water.

MEASURING BOXES. The inside dimensions for the measuring boxes for sand and stone or gravel are given. These boxes are made with straight sides of any kind of rough boards and have no top or bottom. Each end of two opposite sides should be extended and cut away so as to form handles, or else cleats 2 inches by 4 inches can be nailed on for the same purpose. (See Fig. 2.)

WATER. The amount of water given is only approximate. This amount should be used for the first batch; if found too wet for the use desired, the amount must be reduced; if too dry, the amount should be increased. Always use a bucket in measuring the amount of water, as this secures uniform results. See heading "Consistency," on page 24 for a description of the proper wetness of concrete for different purposes.

Fig. 2. MEASURING BOX FOR SAND OR GRAVEL.

THE AMOUNT OF CONCRETE. The fewer voids in the stone or gravel, the greater will be the volume of the concrete. In general, the resulting amount of concrete will be greater than shown in Table No. 1, especially when gravel is used.

1:2:4 CONCRETE. This produces a very strong mixture suitable for all kinds of reinforced concrete, such as floors, beams, girders, columns, etc., subjected to very heavy loading or vibrating machinery. It is practically water-proof and air-tight and can be used on the farm for silos, tanks, cisterns, fence-posts, troughs, etc.

1:2½:5 CONCRETE. This produces a strong mixture often used for reinforced concrete where conditions are favorable. It is best adapted for such structures as machine foundations subject to slight vibration, for sidewalk bases, and ordinary floors which rest on the ground, for sewers and drains, culverts and small heavy arches.

1:3:6 CONCRETE. This produces a strong mixture, but of less strength than those above. It is very rarely used for reinforced concrete in floors, and walls, but more generally used without reinforcement for foundations, footings, gutters, heavy walls, retaining walls, piers, etc.

1:4:8 CONCRETE.—This mixture is used only for work which has to be spread over much surface, but does not carry extremely heavy loads. It is also useful for backing up heavy masonry in large walls, etc.

CAUTION FOR VARIATIONS IN MIXTURE.—If the sand is very fine, the cement used should be increased 10 per cent. to 15 per cent.

If the mixture does not work well (the sand and cement not filling the voids in the stone), the percentage of stone should be reduced slightly, but

first be sure that the concrete is properly and thoroughly mixed. Half-mixed concrete may present defects that are entirely eliminated by turning the mixture over once or twice more.

When water is added to dry cement in the proper proportions, and the whole is thoroughly mixed, the cement becomes a soft sticky paste. It is then in a plastic condition and good cement will usually remain so about half an hour, depending somewhat upon the temperature of the air. It then commences to harden or "set" and must not be disturbed after the mixture has thus begun to set. To disturb it after the initial set is well under way means to destroy entirely the strength of the work.

It must be remembered that Portland cement concrete should be placed in position within twenty or thirty minutes from the time it is first wet.

THE MATERIALS TO USE FOR CONCRETE

CEMENT.—Portland cement is a manufactured product, the principal value of which is its capacity to stick firmly to the various materials used in masonry constructions. It is made by finely grinding special mixtures of certain kinds of rock, burning this powdered rock at a heat which just starts to melt it, and finally by again grinding the cooled, fused mass so as to produce the well known article of commerce called Portland Cement. The name "PORTLAND" as applied to Cement was first used because the color of the manufactured product was a very similar shade to the quarried stone from the Island of Portland on the coast of Dorsetshire, England. The manufacture of high quality cement was commenced in England, Germany and France before it was in this country. It was not until the early seventies that the first American Portland Cement was manufactured in the United States in the Lehigh District of Pennsylvania.

The Lawrence Portland Cement Company, knowing of the purity of the rock, acquired the property in the Lehigh District on which the first cement stone was discovered and obtained also several adjoining cement properties, controlling now about 500 acres of land containing a practically inexhaustible supply of the cement deposit. Unlike most of the other large producers of cement, this Company operates but a single quarry and grinds its cement in but a single immense plant. Furthermore, it uses nothing but the materials which nature has supplied, combining them properly as determined by the most perfect scientific tests and processes. Where the product of several different mills situated in different sections of the country, and perhaps all using widely different materials is put upon the market under one brand name, there is a large opportunity to say the least, for differences in quality to be found in different shipments.

Dragon Portland Cement, however, has the highest reputation for uniformity in cementing quality, strength and color, extending over a long

period of years, and can be absolutely depended upon to maintain this reputation. Some cements are made from slag and refuse from the manufacture of other materials, but all the cement sold from the mills of the Lawrence Portland Cement Co., is made from solid rock and when properly mixed and placed will inevitably return again to a condition similar to natural stone.

SAND.—Sand should be clean, coarse, and free from loam, clay, and all vegetable matter. Do not use very fine sand. If there is a large quantity of fine sand handy, get a coarse sand and mix the two sands together in equal parts; this mixture is as good as coarse sand alone. If the sand is not clean, wash it before using. The simplest way is to build a loose board platform from 10 to 15 feet long, with one end 12 inches higher than the other. On the lower end and on the sides nail a 2x6 on edge to hold the sand. Spread the sand over the platform in a layer 3 or 4 inches thick and wash with a $\frac{3}{4}$ inch garden hose. The washing should be started at the high end and the water allowed to run through the sand and over the 2x6 inch piece at the bottom. A small quantity of clay or loam does not injure the sand, but any amount over 5 per cent. should be washed out.

If fine, dirty sand is used the strength of the concrete will be limited by the quality of the sand and only a part of the full value of the Portland cement will be developed. It is sometimes advantageous to employ a slightly greater quantity of cement so as to make up for the poor effect produced by very fine sand. An extra bag of cement, standing on the board, about a quarter or a fifth of the contents of which is added to each two-bag batch, is the easiest way of securing the extra cement required in such cases. Great care should be exercised to see that the extra quantity is always added. Some experienced contractors reduce the size of the sand and stone or gravel boxes by planing down the edges of the boxes from an inch to an inch and a half according to requirements. The boxes can be restored to their original size by nailing cleats of proper thickness on the planed edge.

By a fine sand is meant one in which the majority of the grains are smaller than $\frac{1}{32}$ of an inch in diameter. For most work, a few grains as large even as $\frac{1}{4}$ inch are not at all detrimental. Care should be taken however to see that the separate grains are not composed of soft stone which can be easily crushed under a knife blade. Neither should the individual grains be flat like flakes of mica or small pieces of slate.

CAUTION.—There are several ways of testing sand to see if it is clean enough to use for concrete work. First rub some of the damp sand between the hands. If they are badly discolored, the sand should not be used. If another test is desired, a handful may be dropped into a pail of water. The water should be 10 inches deep. If the sand on the bottom

cannot be seen through the water at the end of two minutes, the sand is too dirty to be used without washing. Another, and more accurate test is to fill a quart glass fruit jar or a bottle of similar size one quarter full of sand. Add enough water to fill the jar or bottle three-quarters full. Cover tightly and shake thoroughly with a strictly up and down movement. Set carefully on a horizontal shelf or table and allow the sand and mud to settle till the water is practically clear. If the sand in the bottom has a layer of mud over it which is thicker than $\frac{1}{20}$ of the whole depth of sand and mud, the sand is too dirty to use.

STONE OR GRAVEL.—The largest part of concrete is the crushed stone or gravel (pebbles, as they are often called). Other materials are sometimes used in place of stone or gravel, such as ashes, cinders, coke, brick-bats, etc., but it is safer to use crushed stone or gravel, and it should be clean and free from loam, clay, or vegetable matter. Especial care should be taken to inspect the pebbles, as clay is often deposited in thin layers on their surfaces, and this layer prevents the proper binding of the cement. Gravel can be washed in the same way as sand, but more easily, as the water flows more freely through the voids. Dust may be left in the crushed stone, but care should be taken to see that it is distributed evenly throughout the whole mass, and slightly less sand used.

SIZE.—The proper size of stone (or gravel) varies with the form of construction. Use anything up to $2\frac{1}{2}$ inches in diameter for foundations or large thick structures. Use $1\frac{1}{2}$ inches and under (generally about $\frac{3}{4}$ inch) graded, for thin walls and reinforced concrete. Use $\frac{1}{4}$ inch and under for a finish or very hard coating. The best results are obtained from a mixture of sizes graded from the largest to the smallest. This reduces the spaces or voids between the stones or pebbles, and makes a more compact concrete. It also requires less sand and less cement.

NATURAL MIXTURE OF BANK-SAND AND GRAVEL.—Naturally mixed bank-sand and gravel is sometimes found in the right proportions for making concrete. Generally, however, there is far too much sand for the gravel, and great care should be exercised in using this class of material. Unless the mixture runs very even throughout the bank, and is found to be made up of one part sand to two parts gravel, it is better to screen the sand out of the gravel and prepare the materials in the usual way.

WATER.—Water for concrete should be clean and free from strong acids and alkalies. It can be readily stored in a barrel beside the mixing board and placed on the concrete with a bucket, as this allows careful measurement and insures the desired wetness of the mixture.

HOW TO MIX CONCRETE.

WITH the proper materials selected, the next step is to mix properly and with dispatch. On large jobs it is more economical to mix concrete by machine, but for small jobs, using even as much as several hundred cubic yards of concrete, it is cheaper and more expeditious to mix by hand. This is, of course, especially true when only two or three men are available and the work is often interrupted. There are many ways of "hand mixing," all giving the same results. The way described here is believed to be the one best calculated to obtain good results with a minimum of labor. In this description and the accompanying illustrations, there has been taken as a basis a "Two-bag Batch" of 1:2:4 concrete.

CONCRETE MIXING BOARD

A concrete board for two men mixing should be 9x10 feet. It can be made out of 1 inch boards, 10 feet long, surfaced on one side, using five 2x4 inch by 9 foot cleats to hold them together. If 1x6 inch tongue and groove roofers can be obtained, they will do very nicely if fairly free from knots. The object of the surfaced boards is to make the shoveling easy. The boards are to be so laid as to enable the shoveling to be done with, and not against, the cracks between the boards. The boards must be drawn up close in nailing so that no cement will run through while mixing. Knot-holes may be closed by nailing a strip across them on the under side of the board. It is a good precaution against losing cement grout to nail a 2x2 or 2x4 inch piece around the outer edge of the board. Often 2 inch planks are used in making concrete mixing boards, but these are unnecessarily heavy and very cumbersome to move.

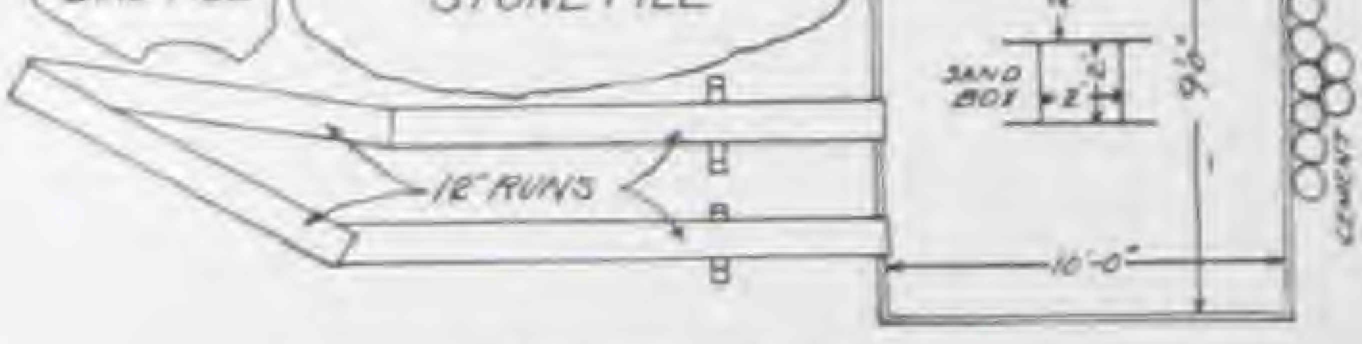
PLACING THE CONCRETE BOARD.—This board is a manufacturing plant, and the advantages of its location should be carefully considered. Generally it is best placed as close as possible to the point at which the concrete is to be deposited, but "local conditions" must govern this point. Choose a place, allowing plenty of room, fairly near the storage piles of sand

and stone. Block up your concrete board level, so that the cement grout will not run off on one side, and the board will not sag in the middle under the weight of the concrete.

RUNS.

Do not use any old boards that are handy for the wheelbarrow runs. Make a good run, smooth, and at least 20 inches wide. These runs should be laid down so as to make a circuit, and a workman will not have to turn around his wheelbarrow and go back the same way he came. If two men tried to do this they would be constantly interfering with each other. With the run in the form of a circuit, the men go only in one direction and cannot interfere and delay the quick depositing of the wet concrete.

Fig 5



Diagram, Fig. 5

MIXING.

With the mixing board placed and the "runs" in position, the concrete plant is ready.

First load your sand in a wheelbarrow from the sand pile, wheel on to concrete mixing board and fill the sand-measuring box, which is placed thereon, about two feet from one of the 10 foot sides of the board, as shown by the diagram in Fig. 5. When the sand box is filled, lift it off as shown in Fig. 6 and spread the sand over the floor in a layer 3 or 4 inches thick.

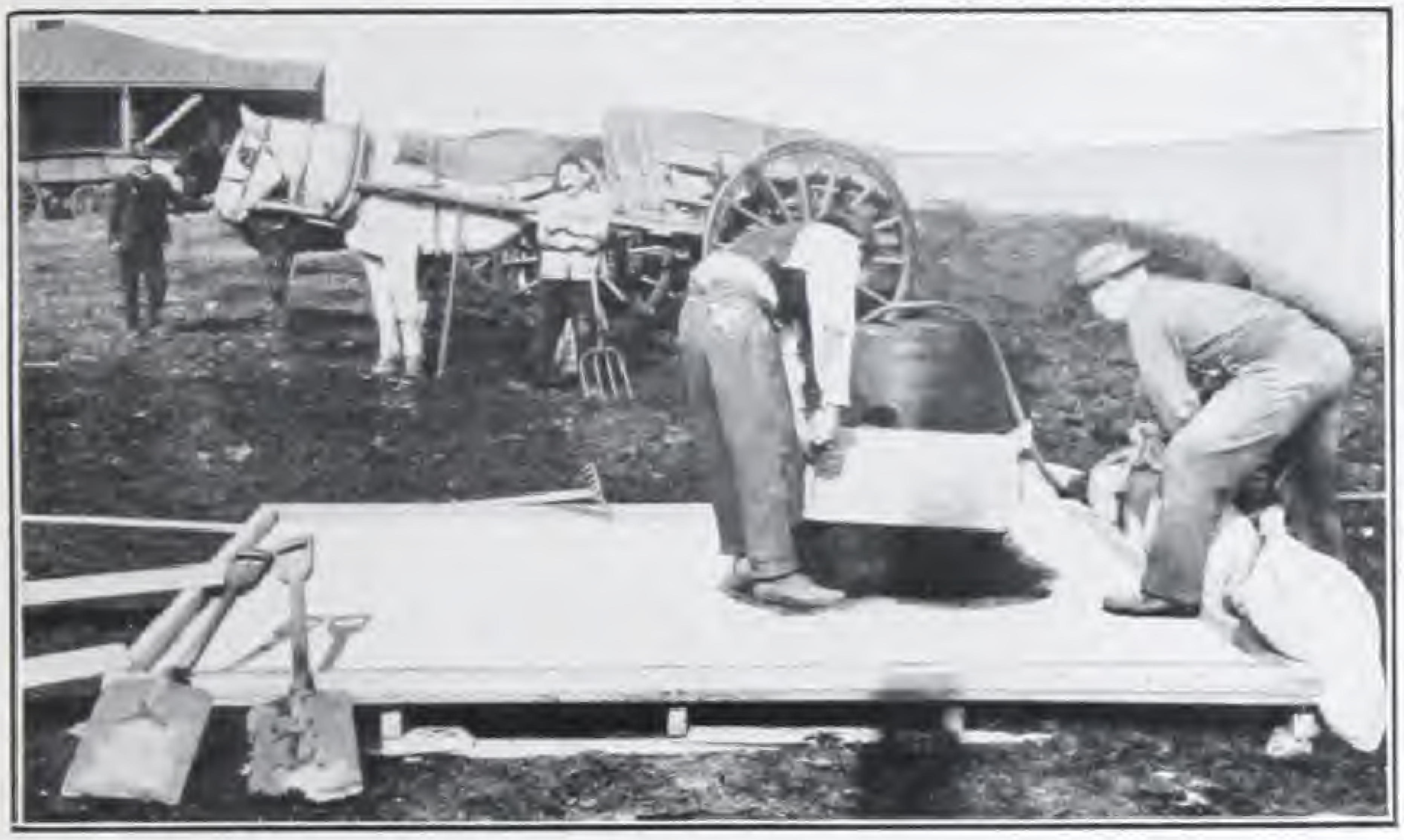


Fig. 6

Take two bags of cement and spread the contents as evenly as possible over the sand. (See Fig. 7). With the two men at points marked "x" and "xx" on the sketch below Fig. 7 start mixing the sand and cement, each man turning over the half on his side of the line A. A. Starting at his feet and shoveling away from him, each man takes a full shovel-load, turning the shovel over at the points marked 1 and 2 respectively in Fig. 7. In turning the shovel, do not simply dump the sand and cement at the points marked 1 and 2 in the diagram under the cut, but shake the materials off the end and sides of the shovel, so that the sand and cement are mixed as they fall. This is essential to a proper mixing. In this way the material is to be shoveled from one side of the board to the other, as shown in Figs. 8 and 9; Fig. 8 shows the first turning, and Fig. 9 the second turning. After two or three such operations the sand and cement should be well mixed and ready for the stone and water.

Fig. 7

Diagram, Fig. 7

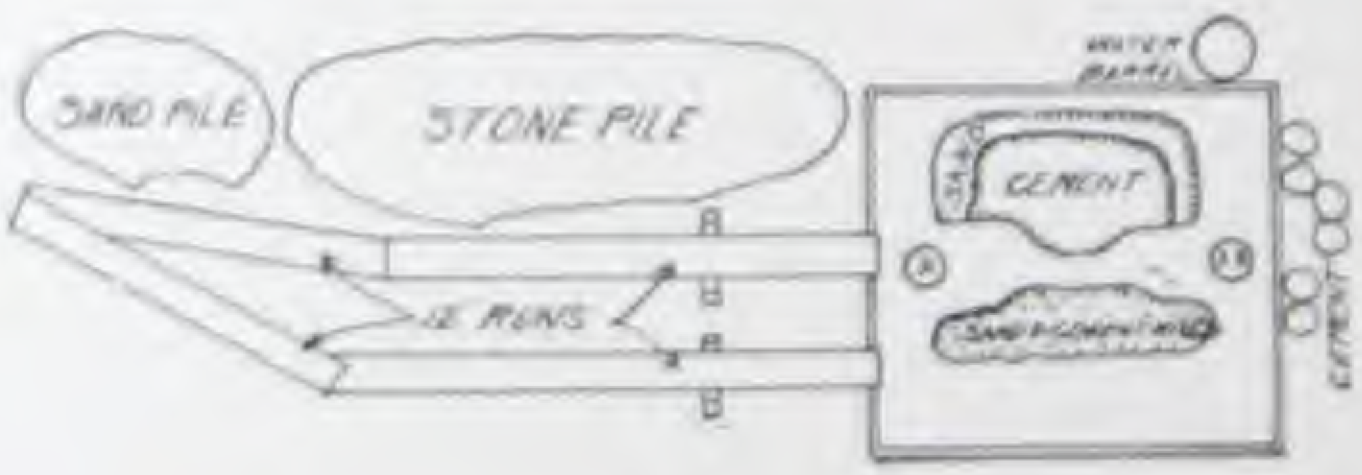
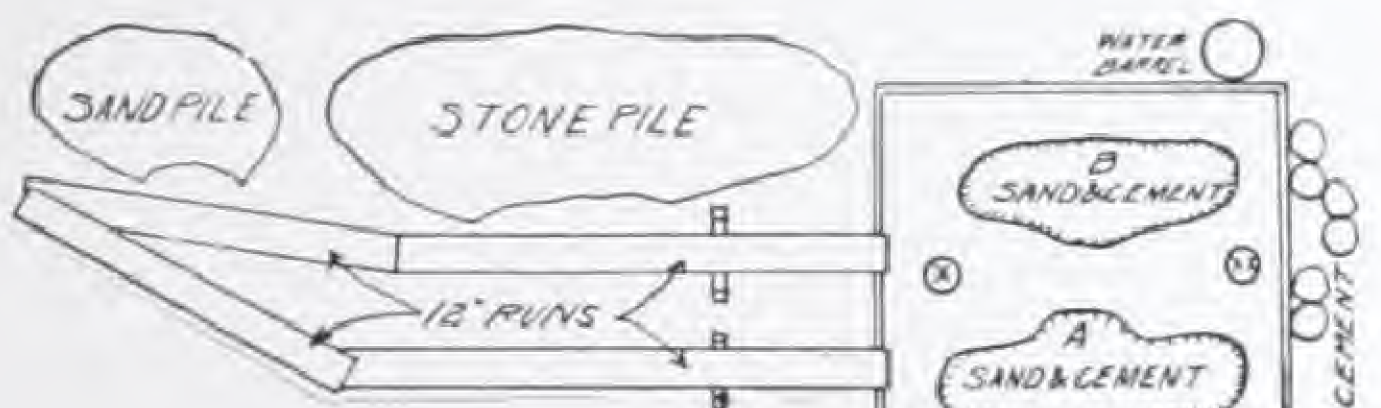


Fig. 8

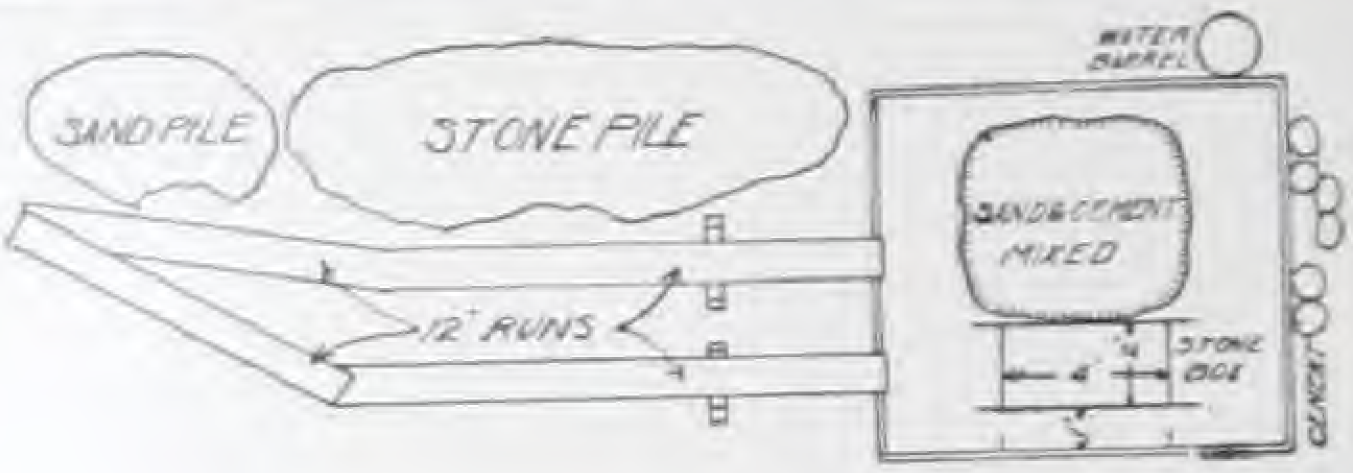
Fig. 9



Diagram, Fig. 9

After the last turning, spread the sand and cement out carefully, place the gravel or stone measuring box beside it as shown in Fig. 10 and fill from the gravel pile. Lift off the box and shovel the gravel on top of the sand and cement, spreading it as evenly as possible. With some experience, equally good results can be obtained by placing the gravel measuring box on top of the carefully leveled sand and cement mixture, and filling it, thus placing the gravel on top without an extra shoveling. This method is shown in Fig. 11. Add about three-fourths the required amount of water, using a bucket and dashing the water over the gravel on top of the pile as evenly as possible. (See Fig. 12.) Be careful not to let too much water get near the edges of the pile, as it will run off, taking some cement with it. This caution, however, does not apply so imperatively to a properly constructed mixing board, as the cement and water cannot get away from it.

Fig. 10



Diagram, Fig. 10.

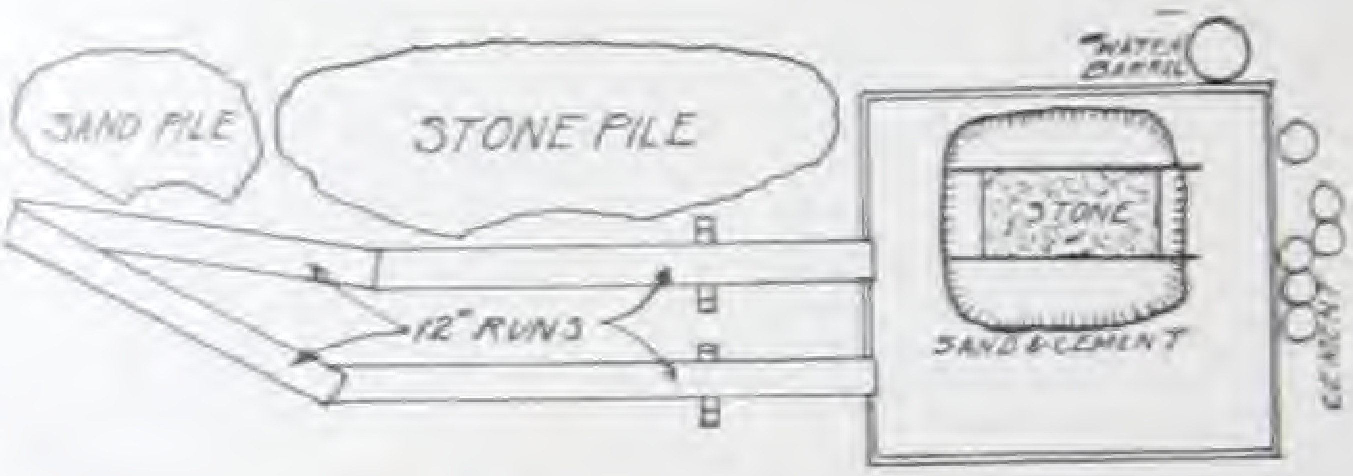


Fig. 11

Fig. 12

Fig. 13

Starting the same as with the sand and cement, turn the mixture over in much the same way, except that, instead of shaking the materials off the end of the shovel, the whole shovel load is dumped as at points 1 or 2 in the diagram under Fig. 7 and dragged back toward the shovelers with the square point of the shovel. This mixes the gravel with the sand and cement, the wet gravel picking up the sand and cement as it rolls over when dragged back by the shovel. (See Fig. 13.) Add water to the dry spots as the mixing goes on until all the required water has been used. Turn the mass back and forth again and again, as was done with the sand and cement. With experienced laborers, the concrete should be well mixed after three such turnings; but if it shows streaky or dry spots it must be turned again. After the final turning, shovel into a pile. (See Fig. 14.) The concrete is now ready for placing.

Fig. 14

MIXING A NATURAL MIXTURE OF BANK-SAND AND GRAVEL.—Spread out the measured mixture of sand and gravel as much as the concrete mixing board will readily permit, add enough water to wet the gravel and sand thoroughly, spread the proper proportion of cement evenly in a thin layer over the sand and gravel, and turn over as previously described, at least three times, adding the rest of the water necessary to get the required consistency while the materials are being turned. Some experience is necessary to work up a natural mixture of bank sand and gravel, and if at all doubtful about the concrete made from it, first screen the sand from the gravel and then mix in the regular way.

Fig. 15

NUMBER OF MEN.—For the above operation only two men are required, although more can be used to advantage. If three men are available, let two of them mix as described above and the third man supply the water, help mix the concrete by raking over the dry or unmixed spots as the two mixers turn the concrete, help load the wheelbarrows with sand and stone or gravel, etc. Fig. 15 shows a third man on the board. In this illustration, he is helping mix the sand and cement by raking it, a most effective practice. If four men are available, it is best to increase the size of the batch mixed to a four-bag batch, doubling the quantities of all materials used. The concrete board should also be increased to 10x12 feet, as shown under "Tools." In this case spread the mixture in the middle of the board, each pair of men mixing each half the pile of material exactly as for a two-bag batch, except that the concrete is shoveled into one big mass each time it is turned back to the center of the board. When more than four men are available, the rest may place the concrete, make new runs, load wheel-

barrows, etc., and take the concrete away from the board as fast as it is mixed. In this case another small concrete board should be placed next to the big "board," so that in the last turning, the batch can be shoveled over on the small board for placing, making room on the big board to mix the next batch. The small platform need be only just big enough to hold the pile of mixed concrete.

MEASURING BY WHEELBARROW.—With a little practice, the sand and stone or gravel can be measured by the number of wheelbarrow loads about as accurately as by the measuring boxes. Care must be taken always to fill the wheelbarrows to the same level. It is wisest, first to build measuring boxes of proper size, and accurately determine how many wheelbarrowfuls of each material are required to fill the boxes.

TOOLS AND PLANT.

List of tools and plant to be used in mixing; giving sizes, quantities, etc.

For convenience, feet and inches are designated by little marks thus: 2' 6", (representing 2 feet and 6 inches). These little marks will be used in describing the sizes of tools and other lengths or widths in the different tables.

CONCRETE BOARD FOR 2-BAG BATCH 9' X 10' IN SIZE.

9 pieces 7/8" x 12" x 10' 0", surfaced one side and two edges.
5 pieces 2" x 4" x 9' 0" rough.
2 pieces 2" x 2" x 10' 0" rough.
2 pieces 2" x 2" x 9' 0" rough.

CONCRETE BOARD FOR 4-BAG BATCH, 12' X 10' IN SIZE.

12 pieces 7/8" x 12" x 10' 0", surfaced one side and edges.
5 pieces 2" x 4" x 12' 0" rough.
2 pieces 2" x 2" x 10' 0" rough.
2 pieces 2" x 2" x 12' 0" rough.

RUNS.—2", 2 1/2", or 3" plank, 10" or 12" wide.

MEASURING BOXES FOR SAND AND STONE OR GRAVEL.

For 2-Bag Batch 1: 2: 4 Mixture:

4 pieces 1" x 11 1/2" x 2' 0" rough.
2 pieces 1" x 11 1/2" x 4' 0" rough.
2 pieces 1" x 11 1/2" x 6' 0" rough.

NOTE: The 2 pieces 4' 0" long and the 2 pieces 6' 0" long have an extra foot in length at each end to be made into a handle, as shown in Figure 2.

For 2-Bag Batch 1: 3: 6 Mixture:

2 pieces 1" x 11 1/2" x 2' 0".
2 pieces 1" x 11 1/2" x 3' 0".
2 pieces 1" x 11 1/2" x 5' 0".
2 pieces 1" x 11 1/2" x 6' 0".

NOTE: The 2 pieces 5' 0" long and the 2 pieces 6' 0" long have an extra foot in length at each end to be made into a handle, as shown in Figure 2.

For 4-Bag Batch:

Double the cubic contents of boxes for 2-Bag Batches and order lumber accordingly.

SHOVELS.—No. 3 square point. (See Fig. 16.)

WHEELBARROWS.—Two are necessary; sheet-iron body preferred.

A RAKE.

WATER-BARREL.

WATER-BUCKETS.—2 gallon size.

A TAMPER.—4" x 4" x 2' 6", with handles nailed to it, will answer.

GARDEN SPADE or "spading" tool.

SAND SCREEN.—Made by nailing a piece of ¼" mesh wire screen 2½' x 5' in size to frame made of 2" x 4". (See Fig. 16.)

Fig. 16. TOOLS FOR CONCRETE WORK.

HOW TO DETERMINE QUANTITIES OF MATERIALS NEEDED.—First figure the number of cubic feet of concrete that will be required for the work in question. Then divide this quantity by the figure in the proper column under Cement, Sand and Gravel for the required mixture shown in first column. The amounts of cement, sand and stone or gravel will thus be found.

TABLE II.

For finding the amount of cement, sand and gravel necessary for a required quantity of concrete of various mixtures.

MIXTURE	Divide total cubic feet of concrete by number below in Cement, Sand and Gravel Columns opposite desired mixture.		
	Cement, Barrels.	Sand Cu. Yards.	Stone or Gravel Cu. Yards.
1 : 2 : 4 Concrete........	17	61	31
1 : 2½ : 5 "	20	59	30
1 : 3 : 6 "	24	57	29
1 : 4 : 8 "	34	55	28

EXAMPLE.—Suppose the work consists of a concrete silo 16 feet in diameter and 30 feet high, with walls 6 inches thick, requiring in all 935 cubic feet of concrete, of which 750 cubic feet is to be 1 : 2 : 4 mixture and 185 cubic feet is to be 1 : 3 : 6 mixture.

In addition, a quantity of cement and sand is to be used of 1 : 1 mixture in "painting" the inside and outside of the silo, being about 400 square yards of surface. One bag of cement and one bag of sand properly mixed with 30 per cent. of water must be provided for each 20 square yards of surface.

SOLUTION:

CEMENT.

Cement for the 750 cu. ft. of 1:2:4 concrete is 750 ÷ 17 = 44.0 bbls.
Cement for the 185 cu. ft. of 1:3:6 concrete is 185 ÷ 24 = 7.2 bbls.
Cement for painting 400 sq. yds. 400 ÷ 20 = 20 Bags = 5.0 bbls.
Total Cement .... 56.2 bbls.

SAND.

Sand for the 750 cu. ft. of 1:2:4 concrete is 750 ÷ 61 = 12.3 cu. yds.
Sand for the 185 cu. ft. of 1:3:6 concrete is 185 ÷ 57 = 3.2 cu. yds.
Sand for painting 400 sq. yds. 400 ÷ 20 = 20 cu. ft. = 0.7 cu. yds.
Total sand .... 16.2 cu. yds.

STONE OR GRAVEL.	cu. yds.
Stone or gravel for the 750 cu. ft. of 1:2:4 concrete is $750 \div 31 =$	24.2
Stone or gravel for the 185 cu. ft. of 1:3:6 concrete is $185 \div 29 =$	6.4
Total stone or gravel, Cubic yards	30.6

Thus the necessary quantities of materials are:

56¼ bbls. of Portland Cement.

16¼ Cu. Yds. of Sand.

31 Cu. Yds. of Stone or Gravel.

It is always wise to order two or three extra barrels of cement if the dealer is at considerable distance, as this avoids any possible trouble that a shortage might cause. Besides, any cement left over always comes convenient for repair work around the house or barn.

PLACING THE CONCRETE.

HOW PLACED.—After the concrete is properly mixed it should be placed at once. Concrete may be handled and placed in any way best suited to the nature of the work, provided the materials do not separate in placing. Concrete may be properly placed by shoveling it off the concrete board directly into the work; by shoveling it into wheelbarrows, wheeling to place and dumping; by shoveling it down an inclined chute, or by shoveling into buckets and hoisting into place. Concrete should be deposited in layers about 6 inches thick unless otherwise specified.

CONSISTENCY.—There are three kinds of mixtures used in general concrete work as follows: very wet, medium and dry.

1. VERY WET MIXTURE.—Concrete is sometimes used wet enough to be mushy and run off a shovel when handling. Such material is used for reinforced work, thin walls, or other thin sections, etc.; no ramming is necessary, but the mass should be well puddled or churned with a blunt stick.

2. MEDIUM MIXTURE.—Such concrete is just wet enough to make it jelly-like. It is used for some reinforced work, and also for foundations, floors, etc. Ramming with tamper or treading with feet is necessary to remove air-bubbles and fill all voids. The concrete shown in Fig. 12 is of a medium consistency, and a man would sink ankle deep if he were to step upon the top of the pile.

3. DRY MIXTURE.—Such concrete is like damp earth, and is used for foundations, etc., where it is important to have the concrete set up as quickly as possible. It must be spread out in a 4 inch to 6 inch layer in placing and thoroughly tamped until water comes to the surface. The proper mixture to use for a given operation will always be specified in the subsequent descriptions of work. The difference between the mixtures is that

the dryer the mixture, the quicker the concrete sets up. In the end, when carefully mixed and placed the results from any of the above mixtures should be practically the same. A dry mixture, however, cannot be used readily with reinforcing steel, it is harder to handle and consequently costs more and must be protected with greater care from the sun or from drying too quickly, and lastly, it is likely, unless "spaded" by most experienced hands, to show voids or stone (or gravel) pockets in the face of the work when the forms are removed.

SPADING.—Concrete of any of the three degrees of consistency mentioned above should be carefully "spaded" next to the form where the finished concrete will be exposed to view. "Spading" consists of running a spade or flattened shovel down against the face of the form and working the tool up and down. This action causes the stone or gravel to be pushed back slightly from the form, and allows the cement grout to flow against the face of the form and fill any voids that might be there, thus making the face of the work present an even homogeneous appearance. Where the narrowness of the concrete section, such as in a 6-inch silo wall, prevents the use of a spade, a one-inch by 4-inch board, sharpened to chisel edge on the end, will do as well. It should be sharpened on only one side and the flat side placed against the form. In the case of a dry mixture, "Spading" must be done with greatest care by experienced hands to get uniform results, but with a medium or wet mixture it is very easy to obtain first-class work. With a wet mixture, spading is only required as an added precaution against the possibility of voids in the face of the work, and is really necessary in few cases.

PROTECTION OF CONCRETE AFTER PLACING.—Fresh concrete should not be exposed to the sun until after it has been allowed to set for five or six days. Each day during that period the concrete should be wet down by sprinkling it with water, both in the morning and afternoon. This is done so that the concrete on the exterior will not dry out faster than the concrete in the center of the mass, during the hot summer months. Old canvas, sheeting, burlap, etc., placed so as to hang an inch away from the face of the concrete will do very well as a protection. This should be wet as well as the concrete. Often the concrete forms can be left in place a week or ten days to protect the concrete during the setting-up period.

CLEANING THE CONCRETE BOARD.—When the day's work is done, carefully clean all the tools, especially the concrete board, removing therefrom with a shovel all the loose cement, sand, and stone. Then scrub the board with a broom and water. If this is not done, small particles of stone are glued to the board by the cement, and render shoveling the next day very difficult.

OTHER CONSIDERATIONS.

1. The binding value of Portland cement is weakened by exposing the concrete to a hot sun during the first four or five days after it has been placed. The Concrete should be covered with canvas or boards, and what is much more important, it should be thoroughly wet about twice a day during hot weather, since the effect of the sun is to dry it too rapidly.

2. A fresh cement mixture can be easily frozen at a temperature below 32° F., and should not be allowed to freeze. It is recommended that mixing concrete be suspended in freezing weather. Should it be necessary to make concrete when the air is so cold write us for particulars on the subject.

PACKING AND SHIPMENT OF CEMENT.—"Dragon" Portland Cement is packed for shipment in cotton sacks, paper bags or barrels.

COTTON SACKS.—Cotton sacks in which "Dragon" Portland Cement is shipped bear the fac-simile of the "Dragon" label and the sack is of the best quality, securely tied. Each sack of cement weighs 95 pounds.

PAPER BAGS.—Paper bags bear the fac-simile of the "Dragon" label, making a strong package for those desiring cement shipped in paper. Each bag of cement weighs 95 pounds.

BARRELS.—The barrels are made of first grade staves, selected heading and patent hoops, making an especially strong, neat package, and well lined with paper. The "Dragon" label is pasted on one end of every barrel, and the word Dragon is stencilled on the opposite end and in three places on the side. Every barrel of "Dragon" Cement weighs 400 lbs. gross.

Shipments of Cement in Cotton sacks are recommended as preferable because most easily handled. The consumer has also an allowance made him for the return of empty sacks, if made in accordance with the requirements of the Cement Company. The sacks must be kept dry, untorn and shipped back by freight.

WHERE TO BUY CEMENT.—Apply to the nearest dealer handling building materials, and ask him to get for you a price on "Dragon" Portland Cement. If he does not handle "Dragon" or take active steps to assist you in securing it, write direct to the main office. There are many other brands of Portland Cement, but if you insist on getting "Dragon" brand you will be certain of obtaining the best and you will know that the material which you actually receive has already been subjected to all of the rigid scientific tests required by the American Society of Testing Materials and in full accordance with the instructions of the American Society of Civil Engineers.

HOW TO KEEP PORTLAND CEMENT.—Cement must be stored in a dry place. It absorbs moisture from the atmosphere with great readiness, and soon becomes lumpy, or even a solid mass, when kept in a damp place. Such cement is useless and must be thrown away. Lumpy cement should not be broken up and used again, even if this can be readily done, as it has lost the greater part of its adhesive value. In storing cement, throw wooden blocks on the floor, place boards on them, and pile the cement, if in sacks, on the boards, as shown in Fig. 17, covering with canvas or roofing paper.

Fig. 17.—METHOD OF STORING CEMENT.

FORMS OR MOLDS.

WET concrete is a very plastic material and in order to give it any desired shape when finally hardened, it is necessary to supply molds, forms, or centers, as they are variously called, to hold the plastic mass during its period of hardening. In addition, the word falsework is usually employed to designate the supports, posts and braces, required under the forms or centers.

These forms are conveniently made of boards of wood for most kinds of work, but in special cases may be of cast iron or sheet metal, or even of plaster of paris or glue, where very intricate work is to be molded. For most work around the farm or the country house, wooden forms are sufficient and for foundations, rough walls and similar structures, even the roughest of planks are entirely satisfactory. The forms usually involve the major portion of the costs of concrete structures, unless the work consists of very large masses which are of the crudest nature. Consequently, the building of the forms should be studied with the greatest care and for all extensive work should be as carefully designed and detailed as all other carpenter work.

The character of the job and the market price of various kinds of lumber will determine the special variety to be used. White pine is the very best material, with spruce, fir, Norway pine and yellow pine in the order named as other suitable kinds. Hemlock has been found to split badly and is not to be recommended for concrete work. Material should be neither very green nor very dry. If very green, it will shrink, while if it has been kiln dried or otherwise similarly treated it will absorb too much water, swell and warp when used. For work in which a good surface is required, the lumber should be dressed on one side, and two edges. The side dressing should be so as to render all boards of uniform thickness, or even surface, and the edges should be tongued and grooved or beveled to secure the best results.

PREPARING DESIGNS OF FORMS.—The points to be considered in preparing designs of forms, besides the costs of the material, are the size and nature of the work; whether the material for the forms may be used over and over to advantage or whether it is wise to buy more material, use it once and then throw it away, as far as any one job is concerned; and what weight the forms and their supports will be called upon to support, during construction and while the concrete is hardening. Very often careless workmen have been known to pile large quantities of material, such as steel reinforcement or lumber upon the forms, which has broken them down. Rather than provide for such excessive loading it is obviously better to design the supports as light as necessary simply to carry the regular concrete, and use care not to overload the falsework with quantities of building materials. Very often, forms and falsework have been designed so small and thin in size as to bend and sag appreciably when the fresh concrete was installed, so that after the work was completed the concrete showed exceedingly bad bulges and uneven lines and surfaces. Occasionally also, forms have been known to break down simply from the load of the fresh concrete. On the other hand, considerable money is often wasted in building forms and supports of so heavy and complicated a nature that it is almost impossible to remove them for further use without damaging them. Sometimes such bulky forms are so cumbersome that the surface of the concrete is necessarily defaced in their removal. Inexperienced men always have great faith in many nails and use them to excess. The ideal design for forms would exclude them almost entirely making use solely of bolts, clamps and wedges.

BRACING.—For sidewalks, curbs and low walls, stakes are first driven into the ground a proper distance apart so that when boards are placed against them, their inside faces will be a distance apart equal to the required thickness of the concrete work. Such methods are shown in Fig. 18. Where the concrete is to be more than six or eight inches high it is necessary to brace the tops of the stakes to keep them from being forced apart by the wet mixture. These braces are often cut on a bevel to fit against the post and simply toe-nailed into them. These nails are very apt to pull out if any great pressure is brought to bear on a brace and it is much better to nail a cleat firmly to the stake and cut the end of the brace so as to fit into the angle formed by the cleat and the stake. At the lower end, each brace should bear against another stake driven into the ground on a slant practically equal to that of the brace, so that its end when cut square will bear directly against the lower stake. This latter stake often needs to have its upper end braced to another one exactly as it braces the one against the concrete work. Unless such precautions are taken, the forms are very apt to bulge badly. Often two or more braces are needed against a single high form at different levels to keep it from bending.

Figure 18 shows a model of how wall forms should be erected, which are necessarily supported solely from the outside. The lower set of braces has the double cut which is essential to good workmanship, while the upper set is poorly arranged, but is according to usual custom. The cross pieces extending from vertical to vertical across the top of the braces are not essential; blocks simply nailed to the verticals being all that is usually necessary. Extra braces might be employed, extending from the tops of the stakes back to the bottoms of other stakes, driven at greater distances from the wall, whenever the wet concrete exerts sufficient pressure to overturn those driven closer to the wall.

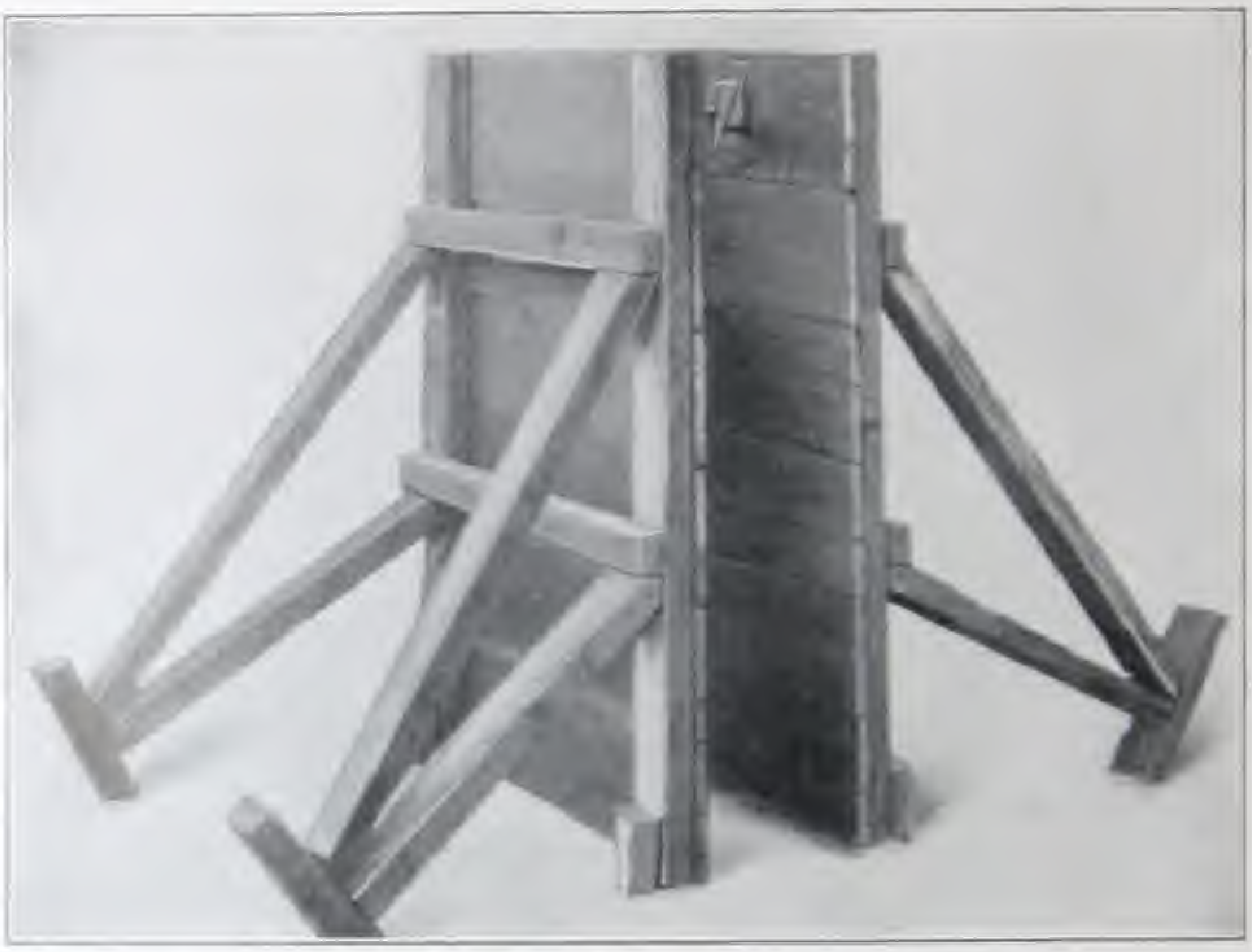


Fig. 18. MODEL OF FORM FOR EXTERNAL BRACING.

METAL TIES FOR FORMS OR FRAMES.—Where walls are more than three feet high and forms are required for two opposite sides, it is best to do away with most of the braces and tie the opposite side forms together with wire or bolts. The use of wire is very common, but has several disadvantages: it cannot be removed from the work and has to be cut off close to the concrete surface so that the ends often rust and discolor the work. It is difficult to adjust the spacing of the forms after concrete has been deposited, should they need such attention. The usual practice is to pass the wire through holes in the forms and around the uprights which hold the boards in place, so as to make a complete circuit with two parallel strands close together between the forms. A stick is then usually employed to twist these two strands until the forms are brought up to the proper spacing, which distance is deter-

mined by a stick cut to proper length placed between the forms close to the wires. A model of such a method of fastening is shown in Fig. 19. The small sticks, used to twist the wire, must always be removed. If any considerable pressure is brought to bear against the forms the wires are apt to untwist and thus be worse than nothing.

Fig. 19. FORM HELD TOGETHER BY WIRE.

A much better method is to insert an extra block between the wire and the upright on one side with a thin wedge between. In order to tighten up the wires it is necessary only to drive in the wedge or insert another in the opposite direction and drive the two to any extent required. It is neces-

sary to employ the extra outside block because the wire will cut into the wood and it would be impossible to drive it without breaking the wires.

BOLTS.—Bolts are very often run through the form boards and an upright on each side, with metal washers and a nut on each end. It is a very easy matter to tighten up a nut and thus adjust the spacing between the forms for a wall, but unless the bolt is removed from the wall within a few days after the concrete is deposited, it will be found so firmly set in the work that it will be impossible to drive it out. It is customary to grease the bolts well when they are put in so as to lessen the sticking of the concrete to them. Sometimes oiled paper is wrapped around the bolt. In all cases where a bolt is used, it leaves a hole completely through the wall which must be plugged with cement and is always apt to show a patched spot on the work. Fig. 20 shows the forms for a house foundation under construction. The bolts

Fig. 20. CELLAR-WALL FORMS HELD TOGETHER BY BOLTS.

are visible at left end, and lever nuts are to be seen along the full length of the forms. To prevent the hole through the wall, a device is found very serviceable which is a combination of the wire and the bolt. Short bolts are run through the form-boards and adjacent uprights and the usual washer and nut placed on the outside end. On the inner end, however, is employed only an ordinary thumb nut or butterfly nut. The two opposite butterfly nuts are fastened together with a double loop of wire very similar to what is often used alone. This arrangement allows the short bolts to be removed from the work leaving the wire and thumb-nut in the work with only short holes in the wall from the surface to the nuts. Of course these shallow holes must

be patched, but the hole entirely through the wall is obviated. In Fig. 21 is shown a model of form work arranged as above described. Temporary spreaders must always be supplied, but great care should be exercised to see that they are all removed before the concrete covers them.

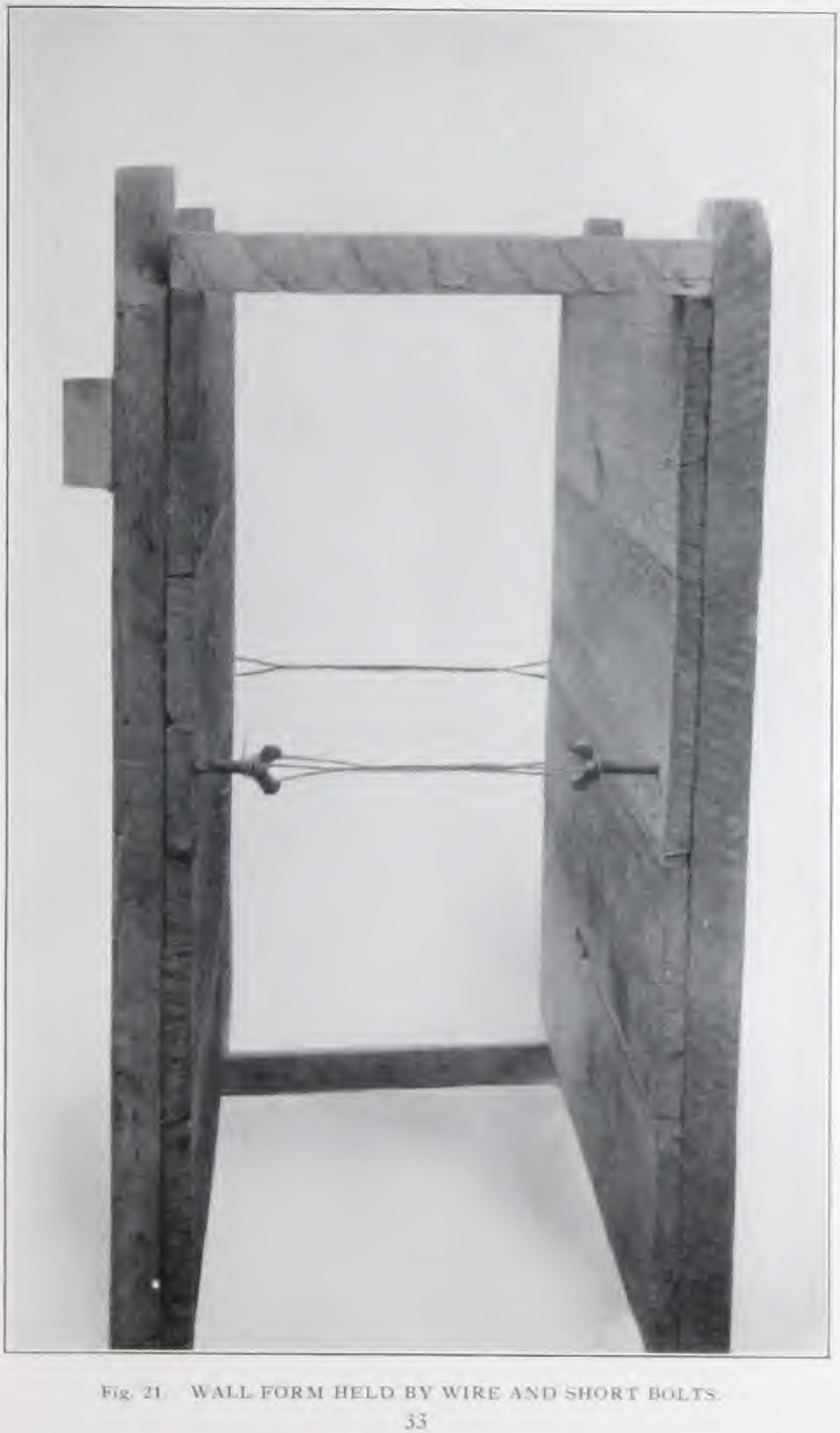


Fig. 21. WALL FORM HELD BY WIRE AND SHORT BOLTS.

THICKNESS OF FORM BOARDS.—When dry concrete is used, it does not matter much about the conditions of the surface of the form boards and the joints between them, but when a wet mixture is to be employed, the joints should be tight, and if a good surface is desired on the finished concrete, the surface of the forms should be smooth and as perfect as possible.

The thickness of the form boards is not of much importance for wall work, except when thin boards are employed, the uprights or studs must be relatively closer together than with heavier stuff. With 7/8 inch material, this spacing is usually 24 inches; for 1 1/8 inch stuff, 3 feet 6 inches; for 1 3/4 inch stuff, it is 4 feet, 6 inches. These studs are 2x4, 4x4 or 4x6 material, according to their length. For the sides of beams, girders, stair

Fig. 22. MODEL FOR OCTAGONAL COLUMN FORM WITH WIRE TIE.

strings, etc., it is usual to employ 1 ¾ inch form boards. For deep beams and girders, ⅞ inch boards with 2x4 cleats are sometimes used, and the same sizes for column forms. In all building construction such as work in connection with floors, supporting walls, and columns, it is essential that the forms be very tight, since small holes or cracks will allow water to run or drip through and some cement is very apt to be carried away, leaving porous places in the work, thus weakening and defacing it. For column forms, bolts and wire are used very much as for wall forms, each of course extending around the outside of the work. With wire it is necessary only to insert an inch board between the wire and the form, and give it a slight wrench sideways, after which it is to be tacked in position with a couple

Fig. 23. MODEL OF SQUARE COLUMN FORM HELD BY BOLTS.

of nails. This contrivance is especially useful for octagonal or circular columns and is illustrated in Fig. 22. It is wisest to use bolts on all four sides of a square column, although sometimes they are installed on two opposite sides only and wooden wedges are employed to hold the other two sides in place. These devices are shown in Fig. 23.

INSPECTION OF FORMS.—Just before concrete is to be placed in important work, all forms should be minutely inspected, all knot holes filled with wet clay or covered with pieces of sheet metal, all extra nails pulled out, all ridges planed down, and all shrinkage joints filled up. During the depositing of the concrete, it is a very wise precaution to have a special man or two delegated to watch out for the alignment and levels of the forms. Lines should be stretched from rigid supports independent of the concrete forms so that measurements can constantly be taken and as soon as any deflection or bulging occurs, wedges can be driven up or nuts screwed further on the bolts to remove the trouble. For this purpose it will be found wise to rest the vertical supports on thin wedges which can be easily driven in and thus raise all work which is found to have settled.

FORMS NOT TO BE REMOVED TOO SOON.—Forms should not be removed until ample time has elapsed to allow the concrete to harden properly. Manifestly, this period will depend on many things, such as the quality of the concrete; the temperature of the atmosphere during the time of placing the concrete and subsequently; the amount of rain or snow which has fallen; the size and strength of the concrete work, etc. For example, large masses may require the forms left in place for only one or two days, while floors may need the support of the false work for a week or a month in summer or winter respectively. The concrete should always be tested by scratching it with the finger nail. Unless it is harder than soft wood, the forms should remain in place. Properly hardened concrete will give a metallic sound when struck with a hammer.

FORM BOARDS TO BE CLEANED.—Forms which are to be used several times should be thoroughly cleaned within a few hours after being removed. Otherwise, the small pieces of cement which stick to the boards will become so hardened that they will not be completely scraped off before the forms are placed in new work, and the fresh concrete will get an even stronger hold on the boards. If these precautions are not observed, the result will be either defaced work when the forms are again removed by tearing off some of the surface concrete, or else the forms themselves will stick so tightly to the concrete that they cannot be removed without being broken. This condition is especially true where any concrete comes in contact with end grain of any wood. In such positions it is likely to become very rigidly attached. To prevent this trouble it is wise to tack a thin strip over the end of any board which will have concrete against it, or to cover it with a piece of sheet metal. In order fur-

ther to prevent sticking it is customary to coat the wood with heavy oil, vaseline, or soap. Experiments have been made with a large number of materials, but an entirely satisfactory method has not yet been discovered. Any kind of grease or oil is apt to prevent proper adhesion of plaster, or paint. Soft soap is excellent, and can be washed off when paint or plaster is to be used. A thorough saturating of the form material with water just before the concrete is installed gives good results, especially with planed material.

OTHER BRACING.—Diagonal and cross bracing of forms for floors, square cellars, cisterns, tanks, etc., is often necessary to withstand wind and accidents of other kinds.

Column and wall forms which are too small for a man or boy to work inside should be made with a small hole at the bottom on two sides at proper intervals so that blocks, shavings, sawdust, etc., can be carefully and completely removed.

Triangular strips are usually placed in the corners of all forms where the concrete would be left with a square corner, so as to make it beveled instead. This reduces the chances for chipping and improves the general appearance.

FOR WALL WORK.—It is often possible to make use of small planes or single planks held in place by bolts and moved up as fast as the concrete hardens. Such a scheme is illustrated in Fig. 20. In all these "systems," so called, it is found wisest to use two lines of forms or plank. The concrete should not be carried to the very top of a plank or line of panels but stopped just short of this line. The lower of the two tiers of panels or planks can be removed and built up on top of the remaining one and the work continued as soon as the forms are properly bolted and spaced. It is sometimes undertaken to use a single line and allow the lower edges of the panels to drop down a few inches below the top surface of the concrete. It is never possible to draw up the forms in their new position as tight as they were before being removed so that the wall is apt to have somewhat the appearance of a side of a clap-boarded house, each new deposit of concrete overlapping slightly that below.

There are several patented plans for doing this work, either in the shape of clamps for the planks, of metal covered forms or of heavy sheets of metal, etc. The best scheme is to make panels of wood about 2 feet by 4 feet, from 2 by 4 studding and ⅞ inch tongued and grooved siding. Two bolts should be used for such a form, placed at the quarter points and just below the top edge. Short blocks should be finally nailed to the back of the forms so that they will interlock when in position, somewhat as the fingers of the hands do when clasped together. At the corners, on the outside, hooks will be necessary in place of the finger-like blocks used on other forms. Panels of this size and design are light and easy to handle. Half inch bolts should be used for most work.

In an exactly similar way the forms for columns, for beams or girders, and for floor slabs are often made in the shape of panels of proper size.

Fig. 24 shows a large reinforced concrete building under construction in which Dragon Cement was used exclusively. The first floor forms are shown in position and the various methods are observed of placing and blocking permanently the column forms, etc. At the right in the foreground is to be seen the bottom form of a girder. The bottom forms for the beams are similarly placed and then the side forms for the latter, as shown.

Fig. 24. REINFORCED CONCRETE BUILDING UNDER CONSTRUCTION.

The spaces between the ends of the beam sideboards are then filled with concrete as can be seen just at the left of the left end of the straight edge, and then the beam side-boards are used to support the cross pieces which serve at the same time as spreaders for the beam boxes and as supports for the panels which will form the bottom boards of the slabs. The skeleton tower in the middle background shows where the concrete is hoisted in an automatic bucket which dumps into the hopper, the spout of which is seen extending out over the floor.

Fig. 25 shows the foundation walls of a barn built of Dragon Cement. The forms for the columns, together with the boxes used for the beam and girder forms are seen in the front section, while the carpenters will be noticed placing the panels for the slab bottoms, in the far section. Note the incline up which the concrete material is to be brought.

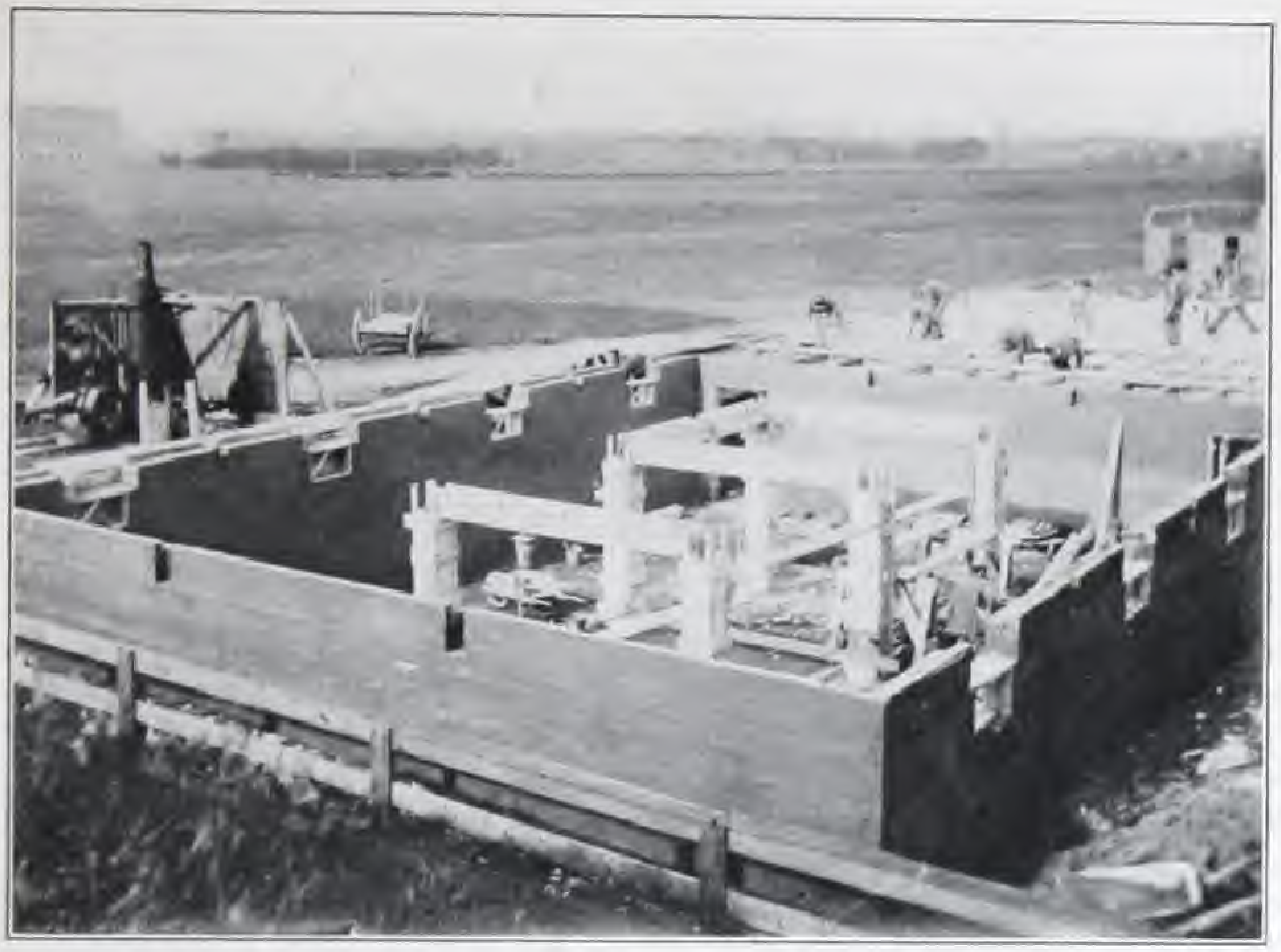


Fig. 25. BASEMENT OF BARN. MASS. STATE FARM.

DRAGON
TRADE MARK
PORTLAND
LAWRENCE PORTLAND
SIEGFRIED, PA
CEMENT COMPANY
CEMENT

FOUNDATIONS, WALLS AND DAMS.

ALMOST invariably, concrete walls are cheaper than others of brick or stone, where they do not extend more than a few feet above the surface of the ground. Very rarely field stones are so plentiful and labor so cheap that rough stone walls can be less expensive than concrete ones. Furthermore, stone walls must usually be nearly twice as thick.

The soil underneath walls of all kinds must be carefully investigated. The excavation must always be carried down so as to secure firm material, at least to the depth that frost penetrates. The excavation should be carried deeper if soft or wet material is encountered at that depth, and where water is likely to accumulate against the foundations, special drains should be laid as described for sidewalk work.

Fig. 26. CONCRETE WALLS FOR STORAGE FILTRATION BED.

Where foundation walls act simply as supports for the timbers or brick work of the superstructure of a house or barn or other building, the concrete work will be of the simplest character. All that is often required is merely the depositing of concrete in trenches excavated in the soil. Where the concrete work is to be brought above the ground level, forms of the plainest character like those described under that heading are all that are required. Such foundations are illustrated in Fig. 25, and plain walls built in the same way but in this case used for a small sewage filtration bed are shown in Fig. 26.

It is a fact of common experience that concrete is accused of being damp. Investigation usually discloses the fact that examples of such concrete work are found of a particularly dense nature. The ordinary condensation which is constantly taking place from the atmosphere is not absorbed into the mass of the material, as occurs with brick or plastered walls, but instead, stands on the surface in drops which collect and run down in little streams. One cure for this condition is to make the work more absorbent by using cinders for the aggregate or by employing a poor grade of concrete, such as 1 to 3 to 6 for example. Another method of prevention is to make the walls in two thicknesses with an air space between. This space serves as an insulator like the air space in a furred and plastered wall.

Instead of grading the earth in terraces, retaining walls are often employed. Like all others, these walls should be carried down below frost line. This varies from as much as six feet to nothing, according to the latitude, four feet being sufficient throughout the northern part of the United States, while in the southern part of the country, where frost does not occur, a depth below ground at least a quarter of the height of the wall above the ground surface should be exacted to prevent excessive pressure on the soil under the wall. The thickness of a retaining wall, against which earth will be placed on one side, and both of the faces of which are to be vertical, should be approximately one-third of the height of the wall above ground. Where the face which is exposed need not be vertical, a wall containing somewhat less con-

Fig. 27. CONCRETE RETAINING WALL TO PROTECT A TREE.

crete can be employed by building it only twelve inches thick at the top, but wider at the bottom of the wall, to such an extent that at the ground level the thickness of the wall is equal to that specified above, for walls with vertical faces.

Fig. 27 shows a retaining wall of artistic but simple design employed to preserve the ground at the roots of a beautiful elm which would otherwise have been killed by the cutting through of a street.

Retaining walls which are more than twenty feet long should be built in sections of about that length, alternate sections being constructed first and the alternate spaces filled afterward. Otherwise the wall will be apt to crack because of shrinkage.

In order to secure an artistic effect, the exposed surface of a retaining wall should be well scoured with water and a piece of old concrete as soon as the forms are removed. The surface thus secured may then be coated with a cement grout composed of equal parts of cement and sand mixed with enough water to give it the consistency of cream and applied with a whitewash brush.

Fig. 28. CONCRETE WALL A CENTURY OLD.

Fig. 28 shows a rubble concrete wall, that is, one in which large stones were embedded while the concrete was still plastic. This wall is on Second Ave., in Brooklyn, N. Y., and is said to be over one hundred years old. It is being removed because of the advance of Suburban Home buildings. It is in an excellent state of preservation and shows the practical indestructibility of concrete. It was originally built for a fence.

Fig. 29. CONCRETE WALL AS AN AUTOMOBILE BUMPER.

Fig. 29 shows a wall which has been erected at the end of a street which terminates against a railroad cut. It was erected to prevent automobiles running over the embankment as they did on several occasions while only an iron fence was in place. This concrete wall is thus an automobile bumper.

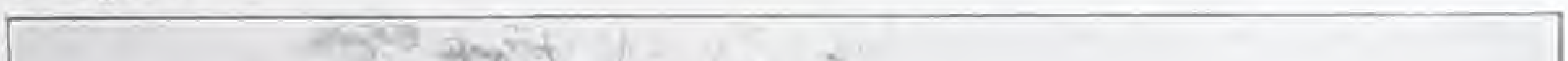


Fig. 30. CONCRETE WALL OF DRAGON CEMENT SURROUNDING A CONNECTICUT ESTATE.

Dragon Cement was used in the construction of the walls shown in Fig. 30 surrounding the estate there pictured.

Fig. 31 shows several retaining walls one above another. Note the steps molded in place leading up from the lowest level to the intermediate one. Note also the round holes in the walls near the telegraph pole, showing where pipes were placed in the concrete for weep holes for the ground water.

Fig. 31. SERIES OF WALLS TO RETAIN AN EMBANKMENT.

Fig. 32 shows a concrete wall built around a park lake. Such structures are indispensable to the preservation of a clean water's edge along which flower beds can be laid out or a sidewalk laid down.

Fig. 32. CONCRETE WALL AROUND A PARK LAKE.

Fig. 33. CONCRETE WALL ALONG A RIVER BANK.

Fig. 33 shows a retaining wall to protect the banks along a river. Note the small box culvert through base of the wall with its flat top.

Fig. 34 shows how a small water course on a country estate has been straightened and the banks protected by the use of low retaining walls.

Fig. 34. METHOD OF STRAIGHTENING A WATER COURSE BY A CONCRETE WALL.

Retaining walls are often built of concrete blocks with most effective results, but such walls should never be of less average thickness than those specified above for mass work, and the blocks should be well cemented together with good Portland cement mortar. Fig. 35 shows such a wall.

It is good practice to bevel the top of a retaining wall on the side toward the earth at an angle of forty-five degrees where the wall is more than twelve inches thick at this point. It is also advisable in many cases with all types of wall to install small pipes or weep holes through the wall just above the lower ground level to carry off water which may collect behind.

A dam built across a stream to form a pond for watering stock or for a supply of ice, can be built exactly like a retaining wall for earth, except that certain special precautions must be taken. In the first place, the foundation must be absolutely solid and the soil under it of such a nature that water will not percolate through it and possibly undermine the structure. Water pressures are almost invariably heavier than earth pressures in the direction which would overturn a dam or retaining wall. Consequently a dam should be made fifty per cent. thicker than the dimensions given for retaining walls. At those portions over the top of which water may flow in case of flood, the down stream side should be given a considerable slant, the upper corner should be well rounded and the space immediately below the dam, into which the water will pour, should be paved with large stones, or else what is called an apron of concrete should be provided. This is nothing more than a strip of sidewalk about four feet wide for a high structure, and correspondingly less for lower ones. Whenever the dam has to resist a head of water greater than about five feet, a competent engineer should be secured to design it and look after its construction.

Fig. 36 shows an old concrete dam with protecting wing walls along the spillway and the arrangement at the gate.

While the dam is being built, it is necessary to divert the water in the stream, or else carry it through the contemplated structure in troughs or pipes, which can afterward be removed or filled with concrete, so as to make an ultimately tight dam. In order to secure as perfect a job as possible, the concrete should all be placed without intermission.

Fig. 35. CONCRETE BLOCK RETAINING WALL

Fig. 36. CONCRETE DAM AND WING WALLS.

STANDARD SPECIFICATIONS FOR PORTLAND CEMENT SIDEWALKS

OF THE

NATIONAL ASSOCIATION OF CEMENT USERS,

with additional notes and comments.

These specifications are applicable to cellar bottoms, feeding floors, driveways, etc., as well as to sidewalks.

MATERIALS.

The cement shall meet the requirements of the specifications for Portland Cement of the American Society for Testing Materials, and adopted by this Association (Specification No. 1), January, 1906.

Dragon Portland Cement is tested at least eight times during the process of manufacture, and is guaranteed to pass these very rigid specifications. It has been successfully used for sidewalks and floors for many years and gives a strong permanent surface of very fine color.

The stretch of sidewalk shown in Fig. 37 in front of the store, was laid of Dragon cement some months previous to Jan., 1893. The reproduction is from an untouched photograph and shows the remarkably fine condition which exists after more than fifteen years of use. Fig. 38 shows another stretch of walk in the same City, Kingston, N. Y., built of Dragon Cement during the year 1893 according to the date mark placed in the work at the time of its completion.

AGGREGATES.

FINE AGGREGATE shall consist of sand, crushed stone, or gravel screenings, graded from fine to coarse, passing when dry, a screen having ¼-inch diameter holes; shall be preferably of silicious materials, clean, coarse, free from vegetable loam or other deleterious matter, and not more than 6 per cent. shall pass a sieve 100 meshes per linear inch.

Any good sand as described on page 11 will pass these specifications.

Mortars composed of one part Portland cement and three parts fine aggregate by weight when made into briquets shall show a tensile strength of at least 70 per cent. of the strength of 1:3 mortar of the same consistency made with the same cement and standard Ottawa sand.

Standard Ottawa sand is a very uniform special sand secured in Illinois, and extensively used for testing purposes. Dragon cement mixed with any good sand will always show results higher than called for in this specification.

Fig. 37. SIDEWALK BUILT OF DRAGON CEMENT IN 1893.

Fig. 38. SIDEWALK BUILT OF DRAGON CEMENT IN 1893.

COARSE AGGREGATE shall consist of inert material, graded in size, such as crushed stone or gravel, which is retained on a screen having ¼ inch diameter holes, shall be clean, hard, durable, and free from all deleterious materials. Aggregates containing soft, flat or elongated particles, shall be excluded.

In some parts of the country soft stones are sometimes employed which will absorb water and swell. They should never be allowed. In some gravel banks, pebbles of similar kinds are often found. Such banks should be carefully avoided.

The maximum size of the coarse aggregate shall be such that it will not separate from the mortar in laying and will not prevent the concrete fully filling all parts of the forms. The size of the coarse aggregate shall be such as to pass a 1¼ inch ring. Water shall be clean, free from oil, acid, strong alkalies, or vegetable matter.

Any good well or other drinking water will conform to this specification.

FORMS FOR SIDEWALKS.

Forms shall be free from warp, and of sufficient strength to resist springing out of shape. All mortar and dirt shall be removed from forms that have been previously used.

The forms shall be well staked to the established lines and grades, and their upper edges shall conform with finished grade of the walk, which shall have sufficient rise from the curb to provide proper drainage; but this rise shall not exceed three-eighths (⅜) of an inch per foot, except where such rise shall parallel the length of the walk.

All forms shall be thoroughly wetted before any material is deposited against them.

Form material should be dressed on at least one side and one edge. The top edge can then be used as a guide in finishing the top surface. The material should be about 2 inches thick, and as wide when dressed as the walk or floor is to be thick, viz., about 5 inches. Stakes should be very substantial, long enough to reach absolutely firm ground and be driven not further than four feet apart.

SIZE AND THICKNESS OF SLABS.

Slabs shall not contain more than 36 square feet or have any dimension greater than 6 feet. For greater areas, slabs shall be reinforced with one-quarter (¼) inch rods, not more than nine (9) inches apart, or other reinforcement equally as strong.

The minimum thickness of the pavement shall not be less than four (4) inches.

Fig. 39. LAYING A CONCRETE SIDEWALK.

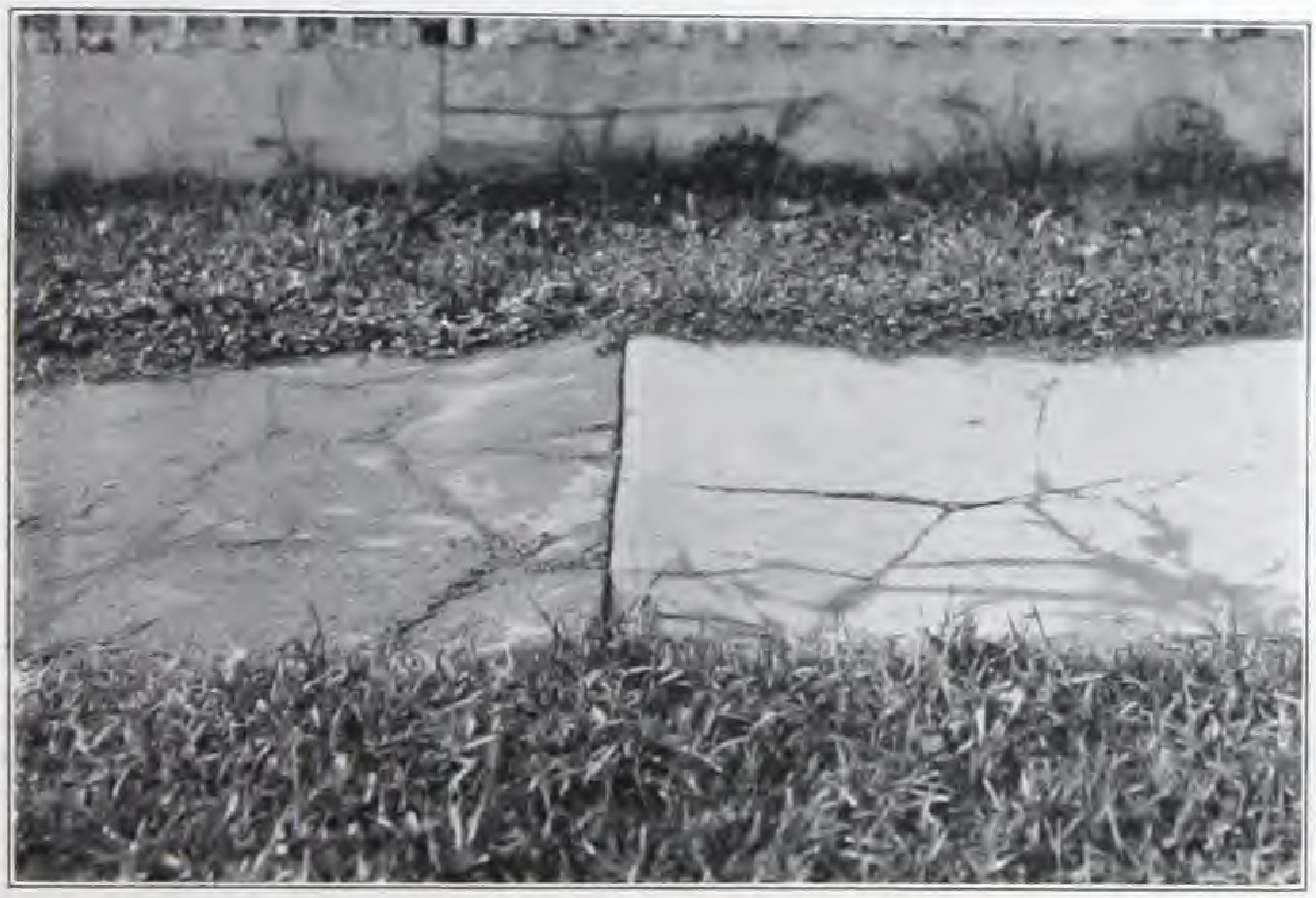


Fig. 40. BULGING OF SIDEWALK DUE TO IMPROPER JOINTING.

When rods are used they should be so placed as to be about the center of the thickness of the slab, and they should run in the direction of the long dimension of the block unless both dimensions are over six feet, when the rods should run in both directions at right angles to each other so as to form a sort of grid.

The slabs or blocks are separated most easily by using a ⅜ inch thick strip of metal or a common clap board of a length just to extend across the walk between the forms; which strip is to be placed in position before the concrete is deposited and held while it is rammed so as to make a partition in the compacted mass. As soon as the ramming is done and the concrete will stand alone, the metal or wooden piece is to be removed and the open space filled with sand. Notches or other marks should be made on the form strips to show where the sand joints have been made. In the case of floors covering large areas, the work should be done just as if they consisted of several narrow strips like sidewalks. Sometimes, such large areas are separated into blocks and alternate ones concreted and finished in the first operation, after which the vacant blocks are filled in as soon as the first ones have properly hardened. This is a much slower and more expensive process. Proper joints should be installed just as in the first method. Work should be stopped for the night against one of these parting strips,—never part way between two of them. A crack will be almost sure to form over the joint between two days' work left in this way.

Fig. 40 illustrates a common trouble always produced by improper width and number of joints. The expansion in this case has bulged up the whole walk.

SUB-BASE.

The Sub-base shall be thoroughly rammed, and all soft spots removed and replaced by some suitable hard material.

The sub-base refers to the earth under the cement walk or floor.

When a fill exceeding one foot in thickness is required, it shall be thoroughly compacted by flooding and tamping in layers of not exceeding six (6) inches in thickness and shall have a side slope of not less than one (1) to one and a half (1½).

When a slope is described as 1:1½ it means that the depth on the slope increases one foot for each foot and one-half extra width.

The top of all fills shall extend at least 12 inches out beyond the sidewalk.

This is important in order to preserve the concrete base from being undermined by rains and washing away the fill.

Thorough compacting is all that is necessary with most soils which are porous and in which water will not be retained under the concrete base so as to freeze and heave the walk. Where the soil is very wet or where the conditions indicate that water is apt to remain under the walk unless special means are taken of preventing it, 3 inch tile or

12 by 12 inch rubble drains should be installed to carry off the water, and usually a heavy bed of cinders, broken brick, coarse gravel or equivalent material from six to twelve inches thick is first laid in a deeper excavation under the proposed walk or floor. This material must be so compacted that it will not settle under subsequent load. A cinder sub-base of this kind is almost invariably required in New York City sidewalk work, and is particularly necessary under cellar floors which might be inclined to dampness. Great care should also be taken to remove all roots of trees from the excavation at least 12 inches deeper than the walk, and a similar distance on all sides. Otherwise the roots are apt to grow, and heave and crack the walk. When valuable trees would be damaged by such cutting, the walk must be kept away from the roots the distance stated.

Fig. 41. EFFECT OF UNDERMINING SIDEWALK BY IMPROPER DRAINAGE.

Fig. 41 illustrates the result of undermining caused by improper drainage, while Figures 42 and 43 show the effect of the roots of trees in lifting a sidewalk.

While compacting, the sub-base shall be thoroughly wetted and shall be maintained in that condition until the concrete is deposited.

The walk or floor usually consists of two layers called the "base" and the "wearing surface." The base is usually 4 inches thick and the wearing surface from ¾ to 1½ inches.

Fig. 42. EFFECT OF TREE ROOTS ON A SIDEWALK.

Fig. 43. EFFECT OF TREE GROWTH ON A CONCRETE SIDEWALK.

BASE.

The concrete for the base shall be so proportioned that the cement shall overfill the voids in the fine aggregate by at least five (5) per cent. and the mortar shall overfill the voids in the coarse aggregate by at least ten (10) per cent. The proportions shall not exceed one (1) part of cement to eight (8) parts of the fine and coarse aggregates.

To determine voids, fill a vessel with sand and let net weight of sand, (that is the weight of sand and pail less weight of pail), equal B. Fill same vessel with water and let net weight of water equal A.

$$\text{Per cent. voids} = \frac{A \times 2.65 - B}{A \times 2.65} \times 100$$

This formula may also be used in determining voids in crushed stone and screenings by substituting for 2.65 the specific gravity of the stone, that is, the weight of a solid cubic foot of stone divided by the number 62.5. This information will be furnished by any Engineer.

The following is a more simple method for determining voids in coarse aggregate: Fill a vessel with the aggregate and let net weight equal B. Add water slowly until it just appears on the surface and weigh. Let net weight equal A. Fill same vessel with water to the same depth and let net weight equal C.

$$\text{Per cent. voids} = \frac{A - B}{C} \times 100$$

Use a vessel of not less than one-half (½)) cubic foot capacity. The larger the vessel, the more accurate the result.

When the voids are not determined, the concrete shall have the proportions of one (1) part cement, three (3) parts fine aggregates and five (5) parts coarse aggregates. A sack of cement (94 pounds) shall be considered to have a volume of one (1) cubic foot.

This proportion is sufficiently near the proper one for most work. Sometimes the large aggregate is omitted from the material of the base, but this is not good practice.

MIXING.

The ingredients of concrete shall be thoroughly mixed to the desired consistency, and the mixing shall continue until the cement is uniformly distributed and the mass is uniform in color and homogeneous.

a. Measuring Proportions. Methods of measurements of the proportions of the various ingredients including the water, shall be used which will secure separate uniform measurements at all times.

b. Machine Mixing. When the condition will permit, a machine mixer of a type which insures the proper mixing of the materials throughout the mass shall be used.

c. Hand Mixing. When it is necessary to mix by hand, the mixing shall be on a water-tight platform and especial precaution shall be taken to turn the materials until they are homogeneous in appearance and color.

d. Consistency. The materials shall be mixed wet enough to produce a concrete of such a consistency as will flush readily under light tamping, and which, on the other hand, can be conveyed from the mixer to the forms, without separation of the coarse aggregate from the mortar.

e. Retempering. Retempering mortar or concrete, i. e., remixing with water after it has partially set, shall not be permitted.

PLACING OF CONCRETE FOR WALKS.

a. Methods. Concrete, after the addition of water to the mix, shall be handled rapidly to the place of final deposit, and under no circumstances shall concrete be used that has partially set.

> The best way to bring the base to a proper level is to provide a gauge board, as it is called, with notches cut in each end so that the lower edge can drop down between the forms below their upper edges just enough to leave a proper thickness for the top coat.

b. Freezing Weather. The concrete shall not be mixed or deposited at a freezing temperature unless special precautions are taken to avoid the use of materials containing frost or covered with ice crystals, and in providing means to prevent the concrete from freezing after being placed in position and until it has thoroughly hardened.

Sidewalks shall be laid in such a manner as to insure the protection of the pavement from injury due to changes in foundations or from contraction and expansion.

Workmen shall not be permitted to walk on freshly laid concrete, and where sand or dust collects on the base it shall be carefully removed before the wearing surface is applied.

WEARING SURFACE.

The wearing course shall have a thickness of at least one (1) inch.

The wearing surface shall be mixed in the same manner as the mortar for the base, but the proportion shall be one (1) cement to two (2) of fine aggregate, and it shall be of such consistency as will not require tamping, but will be readily floated with a straight-edge.

> By floating is meant pushing the mass ahead in front of a straight edge which is shoved along on top of the forms. Very often, the coarsest particles of the fine aggregate are screened out and used for the wearing surface. This produces a somewhat better top than one which contains much very fine material.

The wearing surface shall be spread on the base immediately after mixing, and in no case shall more than fifty (50) minutes elapse between the time that the concrete for the base is mixed and the time that the wearing course is floated.

Otherwise the top may eventually separate from the base.

Fig. 44 shows the result where poor work has not produced a proper bond between the top and bottom coats.

After being worked to an approximately true surface, the slab markings should be made directly over the joints in the base with a tool which cuts clear through the base and completely separates the wearing courses of adjacent slabs.

The slabs shall be rounded on all surface edges to a radius of not less than one-half (½) inch.

Special grooving and edging tools are found best for this purpose. They are to be seen in lower part of Fig. 45.

When required the surface shall be troweled smooth.

The finish given by a wooden float is probably the best for most purposes. Great care must be exercised to have all conditions uniform throughout the whole of the work if it is desired to secure the same color on the whole surface of a floor or walk. Experience has shown that the finished surface color is affected by the color of the cement, that of the sand, the consistency of the mortar, the kind of finishing tool used, the amount of the troweling, the time which intervenes between the placing of the finish coat and the time of trowel-

Fig. 44. RESULT OF POOR BOND BETWEEN BASE AND FINISH COAT.

ing, the moisture in the atmosphere and its temperature, the amount of sunlight directly striking the walk, the kind of protection employed on the surface for several days, whether sand or canvas, etc. It is also to be noted that there is an added tendency toward fine surface cracking or crazing when a wet mixture is used, and especially when a smooth, steel-troweled surface is required.

Fig. 45. TOOLS REQUIRED FOR LAYING CEMENT WALKS AND FLOORS.

The application of neat cement to the surface in order to hasten the hardening is prohibited.

On grades exceeding five (5) per cent. the surface shall be roughened. This may be done by the use of a grooving tool, toothed roller, brush, wooden float or other suitable tool; or by working coarse sand or screenings into the surface.

Special tools are furnished for this purpose by most hardware stores. When the surface is to be troweled smooth, it should be done with a wooden float, using a circular movement and as little effort as possible should be used to secure a good surface since long troweling is apt to work a thin film of cement to the surface which will prove slippery under traffic.

Where color is used it shall be incorporated uniformly and the quantity and quality shall be such as not to impair the strength of the wearing surface.

The wearing surface for drive ways, stock feeding floors or stables should not be less than 1½ inches thick.

SINGLE-COAT WORK.

Single-coat work shall be composed of one part of cement, two parts of fine aggregate and three parts of coarse aggregate, and the slabs separated as provided for in the specifications for two-coat work.

The concrete shall be firmly compacted by tamping and evenly struck off and smoothed to the top of the form. Then, with a suitable tool the coarser particles of the concrete shall be tamped to a depth which will permit of finishing the walk as under "Wearing Surface."

PROTECTION AND GRADING.

When completed, the walk shall be kept moist and protected from traffic and the elements for at least three days.

Special means should be provided to keep off small animals like cats and dogs which often leave foot prints in new work when not properly protected.

Grading of the earth alongside the work after the walks are ready for use on the curb side of the sidewalk, should be one and one-half (1½) inches lower than the sidewalk, and not less than one-quarter (¼) inch to the foot fall towards the curb or gutter. On the property side of the walk the ground should be graded back at least two (2) feet and not lower than the walk; this will insure the frost throwing the walk alike on both sides.

Fig. 39 shows a sidewalk in course of construction. In the foreground the sub-base of earth is to be seen. The side forms are visible along both sides. Just behind the plank across them, the two men are spreading the cinders of the base. A gauge board for bringing the cinders to grade is seen across between the forms beyond the second man. Just beyond the first gauge board is seen a second one for leveling the concrete of the base course. The third man is spreading this concrete while the fourth man is ramming the top layer. The man in the distance is seen with his foot on a straight edge which he has placed across the walk along which to run his trowel so as to make the joint in the top layer. Mixing platforms, measuring boxes, etc., are to be seen at the right.

The illustration of Fig. 46 shows a drain pipe molded directly in the concrete base of a sidewalk, so as to prevent the collection of water behind the walk, and thus avoid the possibility of freezing and consequent heaving. Sometimes gutters are molded in the sidewalk surface, as

Fig. 46. SMALL DRAIN FORMED IN CEMENT SIDEWALK

Fig. 47. COMBINED SIDEWALK, CURB AND GUTTER

represented in Fig. 47 but these are apt to have ice form in them, and they are slippery and dangerous in cold weather. Similar small gutters are often employed at the foot of a down spout or rain leader on buildings to convey the water away from the foundations, so that it will not percolate into the ground, and seep into the cellar, causing dampness and mildew there. (Also shown in Fig. 47).

Fig. 48 illustrates the carrying of a walk over the gutter to form a miniature culvert. Such constructions as this should be reinforced, being computed like a slab of the span of the opening shown for which the table of page 65 gives the amount of reinforcement.

The arched form increases the strength very slightly.

Fig. 49 shows the combined effects of deficient cement, poor sand, poor bonding, imperfect thickness of top coat and improper foundations. The work was only a year old and is to be contrasted with results shown in Figures 37 and 38.

CURBS.

THE trench shall be excavated to a depth not greater than the bottom of the curb and a width not greater than the thickness of the curb plus six (6) inches.

The thickness of the curb shall not be less than six (6) inches.

After the forms are set about one (1) inch of wearing surface shall be placed on the inside of the curb form, then the concrete shall be deposited at one operation and firmly tamped to within one (1) inch of the top of forms. The top wearing surface shall then be placed and be of the same composition as that specified for sidewalks.

Joints shall be made three-fourths (¾) the depth of the curb, continuous with joints of the sidewalk and in no case more than six (6) feet apart.

The forms shall be removed as soon as practical and the faces finished at one operation floating down six (6) inches with a one to one mixture of cement and fine aggregate of sufficient thickness to produce a smooth surface.

Where a combination curb and gutter is required, they shall be cast at the same time and finished at one operation.

COMMENTS.

The curb, if built alongside a cement walk should be entirely independent of it and there should be a wide joint between the two.

The sub-base should be treated exactly as for a walk, with special drainage where necessary.

In order to erect the forms so as to take account of the projections of the footing or spread bottom layer, it is found a good plan to lay down upon the base inside the stake a two by four on edge. The board for the face form is then placed on edge inside this two by four and tacked in place by clips nailed to the stake and the upper edge of the face form.

Fig. 48. ILLUSTRATING SIDEWALK CARRIED OVER GUTTER.

Fig. 49. EFFECT OF DEFICIENT CEMENT, POOR SAND AND BAD WORKMANSHIP

A heavy coat of mortar is first plastered on the inside of this board, after which the space is filled with concrete up to within one-half inch of the top, which is then filled out with mortar like that plastered on the face board. This face form should be removed as soon as the concrete will stand alone and the whole of the front and top surface finished with a steel trowel or wooden float as desired.

Fig. 50. CONSTRUCTION OF A CONCRETE CURB.

During the finishing operation it is often found necessary to apply an additional coat of mortar but this coat should be very thoroughly troweled into the older work so as to secure a perfect bond between the two.

Fig. 50 shows the construction of a concrete curb. Note also the rolls of wire and picket fencing which are used to protect new walks and curbs from being spoiled by the foot prints of small animals like cats and dogs.

A combined curb and gutter can be made by laying a narrow strip of concrete exactly like that for a side walk in direct contact with the street side of a gutter. The two by four against which to place the front board of the gutter must then be blocked in place by short struts between it and the stakes which should be driven as usual.

Dragon PORTLAND CEMENT CONCRETE

FOR

FLOORS, ROOFS, ETC.

EVERYONE knows how easy it is to break a long thin piece of hard plaster or even thin slivers of stone by bending them, and at the same time how difficult it is to crush those materials with simple pressure. It is evident when a long piece of any material is bent by pushing the center downward while the two ends are supported, that all the upper half is made shorter while the bottom half is lengthened. Materials can be lengthened only by being stretched, hence the bottom parts of all beams and floors which are carrying loads must constantly be in a state of tension. Since it is difficult to crush a piece of concrete, but at the same time easy to break it by bending it, the fact must be evident that concrete has very little strength to resist pulling force. It is easy to see that if a concrete beam had a piece of steel fastened securely by some means along its lower surface, the strength of the steel would help the concrete to keep from stretching along its lower portion so that it would be much stronger to resist bending effects. Fortunately, it is an easy matter to fasten together steel rods and concrete by simply imbedding the rods in the concrete while the latter is still plastic. Obviously, the closer to the bottom of the beam such steel rods are placed (so long as they are securely imbedded), the stronger the beam will be. In the table on page 65, in the second column, is given the proper distance inside the concrete which the centers of the rods should be placed for different thicknesses. They should also be spaced at nearly equal distances apart.

Total thickness of beam or slab one foot wide in inches	Thickness of fire-proofing below center of steel in inches	Required area of steel in square inches per foot width	Spans in feet corresponding with loads per square foot given at the head of each column, (over and above the weight of the concrete and steel) which will be carried by the thickness of slab found at the left on any line.																
			50	75	100	150	200	250	300	400	500	600	700	800	900	1000	1500	2000	2500
2	¾	0.115	4.3	3.7	3.4	2.8	2.4	2.2	....	....	....	....	....	....	....	....	....	....	....
2½	¾	0.162	5.7	4.9	4.6	3.8	3.4	3.1	2.8	2.5	2.3	....	....	....	....	....	....	....	....
3	¾	0.208	7.0	6.2	5.7	4.8	4.3	4.0	3.7	3.2	2.9	2.7	2.4	....	....	....	....	....	....
3½	¾	0.254	8.4	7.4	6.8	5.8	5.2	4.8	4.4	3.8	3.5	3.2	3.0	2.8	2.7	2.5	....	....	....
4	1	0.277	8.8	7.8	7.2	6.3	5.6	5.2	4.7	4.2	3.7	3.5	3.3	3.1	3.0	2.8	2.3	....	....
4½	1	0.324	9.9	9.0	8.2	7.2	6.4	5.8	5.4	4.8	4.4	4.1	3.8	3.5	3.4	3.3	2.7	2.4	....
5	1	0.370	11.0	10.0	9.2	8.2	7.3	6.7	6.2	5.4	5.0	4.6	4.3	4.0	3.9	3.7	3.1	2.7	2.4
5½	1	0.416	12.0	11.1	10.2	9.1	8.2	7.4	6.8	6.2	5.6	5.2	4.8	4.5	4.3	4.1	3.4	3.0	2.7
6	1¼	0.440	12.4	11.4	10.5	9.3	8.5	7.8	7.2	6.4	5.8	5.4	5.0	4.7	4.5	4.3	3.5	3.1	2.8
7	1¼	0.532	14.3	13.2	12.3	10.9	10.0	9.3	8.6	7.7	6.9	6.4	6.0	5.7	5.4	5.2	4.3	3.7	3.3
8	1¼	0.625	16.2	15.0	13.8	12.5	11.5	10.7	9.8	8.8	8.1	7.5	7.0	6.6	6.3	6.0	5.0	4.3	3.9
9	1½	0.694	17.1	15.8	15.0	13.5	12.5	11.6	10.7	9.6	8.9	8.3	7.8	7.4	7.0	6.7	5.5	4.8	4.3
10	1½	0.786	18.7	17.5	16.6	15.0	13.8	12.8	12.0	10.9	10.0	9.3	8.7	8.2	7.8	7.5	6.2	5.4	4.9
12	1½	0.970	21.5	20.3	19.3	17.7	16.3	15.5	14.4	13.2	12.2	11.3	10.5	10.0	9.6	9.0	7.4	6.5	5.9
14	1½	1.156	24.3	22.9	21.9	20.2	18.7	17.9	16.8	15.4	14.2	13.3	12.4	11.7	11.2	10.6	8.8	7.7	7.0
15	1½	1.250	25.5	24.2	23.2	21.4	20.0	19.1	17.8	16.4	15.2	14.2	13.3	12.5	12.0	11.4	9.4	8.3	7.6
16	1½	1.340	26.7	25.4	24.5	22.6	21.2	20.0	18.9	17.4	16.2	15.2	14.2	13.4	12.8	12.2	10.2	8.9	8.1
18	1½	1.528	29.0	27.7	26.7	24.9	23.4	22.0	21.0	19.3	18.0	17.0	15.8	15.2	14.5	13.7	11.4	10.1	9.2
20	1½	1.712	31.3	30.0	28.8	27.0	25.6	24.2	23.1	21.3	19.8	18.7	17.6	16.8	16.1	15.4	12.8	11.3	10.3
22	1½	1.900	33.5	32.0	30.9	28.9	27.5	26.2	25.1	23.0	21.6	20.4	19.3	18.4	17.7	16.8	14.2	12.5	11.3
24	1½	2.082	35.5	33.8	32.7	30.9	29.5	28.8	26.8	24.8	23.3	22.0	20.8	20.0	19.2	18.2	15.4	13.7	12.4
26	1½	2.270	37.4	35.9	34.7	32.9	31.3	30.0	28.7	26.6	25.0	23.7	22.5	21.5	20.7	19.7	16.8	14.9	13.5
28	1½	2.456	39.3	37.9	36.7	34.8	33.1	31.7	30.4	28.3	26.7	25.3	24.0	23.1	22.2	21.2	18.2	16.1	14.6
30	1½	2.635	41.3	39.5	38.5	36.7	34.9	33.5	32.2	29.9	28.3	26.8	25.6	24.5	23.8	22.6	19.4	17.3	15.7

Table III is based on following conditions:—Ratio of noduli 15, linear variation of stress, maximum compression in concrete 650, maximum tension in steel 16000, no tension in concrete, ratio of effective areas 0.0078, beams and slabs simply supported at ends, dead-weight of materials included in computation.

Diameter in inches	Area in square inches	Weight per foot in pounds	Sectional Area of Steel per foot width of beam or slab when spaced the number of inches apart shown at the head of each column.													
			2	2½	3	3½	4	4½	5	5½	6	7	8	9	10	12
¼	.0491	.167	.29	.23	.20	.17	.15	.13	.12	.11	.10	.08	.07	.07	.06	.05
5/16	.0767	.261	.46	.36	.31	.26	.23	.20	.18	.17	.15	.13	.11	.10	.09	.08
3/8	.1104	.376	.66	.53	.44	.38	.33	.29	.26	.24	.22	.19	.17	.15	.13	.11
7/16	.1503	.511	.90	.72	.60	.51	.45	.40	.36	.33	.30	.26	.23	.20	.18	.15
½	.1963	.668	1.18	.94	.78	.67	.59	.52	.47	.43	.39	.34	.29	.26	.24	.20
9/16	.2485	.845	1.49	1.19	.99	.85	.75	.66	.60	.54	.50	.43	.37	.33	.30	.25
5/8	.3068	1.043	1.84	1.47	1.23	1.05	.92	.82	.74	.67	.61	.53	.46	.41	.37	.31
11/16	.3712	1.262	2.23	1.78	1.48	1.27	1.11	.99	.89	.81	.74	.64	.56	.49	.45	.37
¾	.4418	1.502	2.65	2.12	1.77	1.51	1.32	1.18	1.06	.96	.88	.76	.66	.59	.53	.44
13/16	.5185	1.763	3.11	2.48	2.07	1.78	1.56	1.38	1.24	1.13	1.04	.89	.78	.69	.62	.52
7/8	.6013	2.044	3.61	2.88	2.40	2.06	1.80	1.60	1.44	1.31	1.20	1.03	.90	.80	.72	.60
15/16	.6903	2.347	4.14	3.31	2.76	2.37	2.07	1.84	1.66	1.51	1.38	1.18	1.03	.92	.83	.69
1	.7854	2.670	4.71	3.77	3.14	2.69	2.36	2.09	1.88	1.71	1.57	1.35	1.18	1.05	.94	.78
1⅛	.9940	3.380	5.96	4.77	3.98	3.41	2.98	2.65	2.39	2.17	1.99	1.70	1.49	1.33	1.19	.99
1¼	1.2272	4.172	7.36	5.89	4.91	4.21	3.68	3.27	2.95	2.68	2.45	2.10	1.84	1.64	1.47	1.23
1⅜	1.4849	5.049	8.91	7.12	5.94	5.09	4.45	3.96	3.56	3.24	2.97	2.55	2.23	1.98	1.78	1.48
1½	1.7671	6.008	10.60	8.48	7.07	6.06	5.30	4.71	4.24	3.86	3.53	3.03	2.65	2.36	2.12	1.77

Table IV of Areas, Weights per foot and Areas per foot width of beam or slab for various spacings of round rods of usual diameters.

CARE IN PLACING RODS.—Great care should be exercised to see that the rods are placed and remain exactly where it is intended that they should be. Since the figures in the table III are the distances from the centers of the rods to the outside, it is necessary to subtract from those figures one-half the diameter of the rod to get the thickness of the concrete between the outside of the rod and the outside of the concrete. Suppose for example, that it had been decided to use a beam 10 inches thick. From the table it is found that the centers of rods for this thickness of beam should be placed 1½ inches inside the concrete. Suppose further, that ¾ inch rods are to be used. One-half of this diameter is ½ of ¾ or ⅜ of an inch. The thickness of concrete between the rod and the outside is then 1½ less ⅜ or 1⅛ inches. In order to hold up the rods 1⅛ inches from the bottoms of the forms it is often found convenient to mold some little mortar blocks just 1⅛ inches square, and from three to ten inches long. Through the center of each block should be run a piece of small wire such as is used for holding stove pipe. This can easily be done by pushing the wire down into the wet mortar, and it is always found convenient to leave an inch or two of each end of the wire projecting from one side near each end of each block. These blocks are easily made by securing a long smooth board just as wide as the length of the blocks. Clamp along the sides of this board strips which extend upward within an eighth of an inch of the thickness of the desired mortar blocks. Next secure some wooden blocks the size of the required mortar blocks and lay them on the board with alternate open spaces between, just as wide as the concrete blocks are to be. This can readily be done by putting all the wooden blocks in place, wedging alternate ones in tight by small pieces about the size of a match at each end, and then removing the unwedged blocks. The openings thus formed are to be filled with mortar which can be easily spread and worked into the slots, and the top scraped off by using a narrow strip of wood or a trowel. The wires are then to be pushed down into place and after twenty-four hours the mortar is usually so hard that the clamps can be removed, after which the sides will fall away, and the alternate wood and mortar blocks can be removed from the board which should be carefully cleaned together with the wooden blocks for a second and succeeding uses. The mortar blocks should be allowed to harden for at least a week before using. They are the first thing to be placed in the forms with the reinforcing rods on top of them. The projecting wires will be found convenient to wrap around the rods to hold the blocks and rods in place.

There are many varieties of special patented rods and other kinds of reinforcing materials, but many engineers believe that the ordinary smooth round or square iron or steel bars to be obtained from every blacksmith shop are entirely satisfactory, provided it is seen that each end of each rod is bent through a half turn to make an open hook. Where rods come end

to end, these hooks should be inter-locked, and drawn tight by sliding the rods apart as far as possible.

In order to make use of the table, the load on the floor must be considered as divided up into strips just one foot wide, laid side by side. It is the thickness of this strip which is given in the table, together with the amount of reinforcement required in it. A strip which is much thicker than it is wide is called a beam or girder, but the table will give information about such members just as perfectly as about thinner floor slab strips. The table is so made that it already takes account of the weight of the concrete and steel composing the strip or beam, and anyone using the table has only to know the extraneous or additional load which is to be carried. For most cases, the following additional load or "live" load (as it is often called) is ample.

Flat roofs	50 lbs. per square foot.
Dwelling floors	60 " " " "
Stable floors	100 " " " "

Hay loft per ft. in height of storage room for loose hay 20 lbs.

Hay loft per ft. in height of storage room for baled hay 32 lbs.

Earth fill over the tops of buried tanks, etc., 100 lbs. per foot of depth.

Ordinary suburban traffic on sidewalks 100 lbs.

Slab culverts in roads where steam rollers may be used about 500 lbs.

EXAMPLES.—Several varieties of problems may arise in which the table will give immediate results, for example:

What thickness of slab is required for a stable floor, where the slab will have a span of eight feet center to center of supports? In the table it is seen that for a 100 pound load a 4½ inch slab will span 8.2 feet, while a 4 inch one will go only over 7.2 feet. The proper thickness to use therefore is 4½ inches.

It is found that in a certain location, a 6 inch slab has been used with a span of 10 feet. What extra live load will this floor safely carry? According to the table, a 6 inch slab on a 10.2 foot span will safely carry 100 pounds per square foot of top surface provided a proper amount of reinforcement has been employed.

For what span will a 6 inch slab culvert be available in a country road where a steam roller may pass and where two feet of earthfill will be used over the top of the culvert? Two feet of earth will weigh 200 pounds per square foot. This is to be added to the 500 pound equivalent load of roller making 700 pounds. According to the table, this load on a six inch slab corresponds to a 5 foot span.

USES OF TABLE.—In a very similar manner, the table can be used for determination of the proper sizes of beams. It must not be forgotten, however, that the table is prepared for a standard width of twelve inches and for any other width a proper change in loads must be made. Obviously a beam 6 inches wide will carry only half as much load as one 12 inches wide if the depths are equal. Hence if a beam six inches wide is desired for a given load, the table can be used to find the depth of a beam 12 inches wide which will carry twice the desired load. After this has been found, it is clear that the six inch beam desired will then safely carry half as much load.

Suppose for example that a load of 450 pounds per running foot is to be carried on a 16 foot span, and a beam only six inches wide is desired. A beam 12 inches wide would carry twice as much or 900 pounds. According to the table, 900 pounds per foot will be safely carried 16 feet by a slab 20 inches deep, because such a slab will be safe for even 16.1 feet. 20 inches is too deep for a beam only 6 inches wide, because of the trouble of working the concrete down around the rods in a proper manner.

If an eight inch wide beam is proposed then a twelve inch beam would carry half as much again safe load, which in the case supposed above will be $1\frac{1}{2}$x450=675. From the table for a 700 pound load it is seen that a beam 18 inches deep will be safe on a span of 15.8 feet while for a 600 pound load the span is 17.0. By proportion, a 675 pound load would be safe on a 16.7 foot span.

$$(\text{Span}-15.8) : (17.0-15.8) :: (675-600) : (700-600)$$
$$(\text{Span}-15.8) : 1.2 :: 75 : 100$$
$$(\text{Span}-15.8)=0.900$$
$$\text{Span}=16.7$$

Probably a beam 17 inches deep would be about right, but 18 inches is a better size because lumber can be secured of a width to build the forms for such a beam without ripping. It is seen that the beam 6x20 takes less concrete material than the one even 8x17, so that it is evident the deeper it is possible to make a beam the less it will cost within certain practical limits.

WIDE BEAMS.—If the depth of a beam is limited, then its width must of course exceed what have thus far been considered good practical widths. Suppose for example that the depth of the beam in the previous example cannot for some reason be greater in vertical dimension than 12 inches. According to the table this depth and a 16 foot span falls between a 200 and a 250 pound load, one having a span of 16.3 and the other of 15.5. By proportion the actual load for just a 16 foot span can be found to be 231 pounds.

$$(\text{Load}-200) : (250-200) :: (16-15.5) : (16.3-15.5)$$
$$(\text{Load}-200) : 50 :: 0.5 : 0.8$$
$$(\text{Load}-200) = 31$$
$$\text{Load} = 231$$

Since a load of 450 pounds per foot has to be carried, the width of beam required will be as many times 12 inches (the width of beam in the table) as 450 is times 231. $450 \div 231 = 1.95$. $1.95 \times 12 = 23.4$.

With a beam almost 24 inches wide the rods are spaced further apart than really necessary if comparatively large diameters are employed. Consequently an engineer under such conditions would probably put them so that they were not more than two diameters apart in the clear, grouped at the center of the bottom of the beam, and would then cut away the concrete on the two lower corners, so as to make the beam into a sort of large T. Plenty of concrete should be left outside the outer rods; and the top part of the T, called its flanges, should have a vertical thickness not much less than half the full depth of the beam unless special reinforcement is employed, which it is wisest to let only an experienced engineer determine.

For ordinary beams, engineers have devised several schemes of reinforcement which are more effective than the use only of straight rods with hooked ends.

SIZES OF BEAMS.—Fig. 52 shows one such arrangement, which has proved very satisfactory and many other similar devices are on the markets. The design of a beam should be submitted to an experienced engineer whenever it cannot be immediately determined from the quantities given in the table. Where the panels are continuous, and equal in size and more than three in number in the direction in which the reinforcing rods run either in slabs or beams, and when slabs or beams are six inches or more in thickness, it is much better to place half the steel close to the top of the beam or slab just as if the member were being made up side down, with the other half placed as usual near the bottom of the slab or beam. In the case of such continuous members it is necessary to use a total of about one-third more steel than when it is placed solely near the bottoms. The splices in the top rods must be made near the centers of the spans, while those of the bottom rods must be made near the supports. Unless such an arrangement of reinforcement as that described above is employed, cracks are likely to occur over the supports. When both top and bottom rods are employed it gives a stronger job to tie them together, by vertical or diagonal wires in the vicinity of the supports such as are shown in Fig. 52. If diagonal ties are employed, they should almost always be made to slope downward away from the supports.

Fig. 52

AN EXAMPLE OF A COMBINATION OF RODS FOR BEAM REINFORCEMENT
COMBINED IN A UNIT FRAME.

Fig. 53 shows a porch slab constructed of reinforced concrete, together with steps leading thereto, and heavy walls on each side of the steps. The slab in this instance must be for a span between the brick piers, and of a width of only about two feet, because that portion of the slab over the piers must act as a beam to support the slab extending from the brick wall to the outer edge of the porch.

Fig. 53. PORCH SLAB AND STEPS OF CONCRETE.

STEPS OR STAIRS.

THERE are several varieties of concrete steps or stairs and various methods of constructing them.

One of the simplest ways is to have a carpenter make a box with suitable means of handling, and provided with a loose piece of board placed against the vertical side to produce a depression under the overhang of the tread. The back side should be given a strong bevel so that the mold may be easily withdrawn and the whole so arranged that the step will be upside down when the concrete is placed in the mold.

SPECIAL FORMS.—Special boards longer than the molds by several inches should be provided, with several cleats nailed on one side in order that one's hands can be easily slid underneath the board for picking it up. After the concrete (which should be only moist, not wet) is placed in the mold and properly tamped, this board should be laid on top with the cleats upward and then the whole mold turned over so that the concrete now rests on the cleated piece. The box can then be carefully lifted off, giving it a slight rap on one side if it does not slip easily. The loose piece can then be carefully removed and there will remain a completed step. The box can be made as long as desired except that with steps longer than about three feet it is necessary to mold in some pipe or iron rods to prevent cracking during handling, and the cleated board must be made very stiff so as not to spring from the weight of the fresh concrete and allow it to break. Steps formed in this way can be handled exactly like stone steps. Concrete mixed about 1 to 3 to 6 usually gives good results provided plenty of mortar is first placed in the bottom of the form and against the loose board to make the top and front surfaces of the completed step.

SIZE OF STEPS.—The steps should be not more than nine inches thick, depending on the desired steepness of the flight. Seven inches makes a very comfortable step. The width of the mold should equal the width of the desired step plus three inches on which to rest the next higher one. Any good mason can set steps made in this way and the result should be highly satisfactory for garden walks, porch steps, etc., when care is exercised to secure good surfaces from the molds, and where suitable foundations are available.

REMOVAL OF EARTH.—When the earth is of such a character that it will easily stand for sometime after cut into the form of steps by the use of a sharp spade, concrete steps can readily be cast in place. The earth should first be cut to a uniform grade under the steps with the sides cut vertically at each end. Two or three planks should be prepared with notches cut into one edge of each exactly like those used for the strings of wooden flights. These should be put in place, but of course reversed from the position occupied in a flight of wooden steps. By making each plank longer than the desired steps, it can be securely fastened to a stake at each end driven firmly into the ground. Boards should be nailed to the vertical sides of the notches so that the concrete will be retained in place against them to form the fronts of the risers. These should be plastered inside with mortar just as described for the building of a curb, and after the concrete is deposited the top should be given a wearing surface like that of a sidewalk. By forming a groove in the upper edge of each front board, a nosing will be molded in the finished work. This feature is very often omitted, each step being given only a slightly rounded edge.

SIDE PIECES.—If it is desired that there be a side piece for the flight, all that is necessary is to place the outside notched string pieces inside the excavation a short distance equal to the desired thickness of the side pieces. The concrete is then to be placed in this space just as for the steps. It is now necessary to have at least the outsides of these strings planed smooth, and neat rounded joints should be made between the front boards of the steps and the form strings. If the concrete sides are to come up above the ground surface, an outside form must be employed like the one for the face of a curb. By carefully preparing the forms, very complicated and artistic work can be secured with platforms, winding flights, and other features. Some of the photographs show concrete blocks employed for the side pieces.

SOLID FLIGHTS.—Manifestly, in the case of monolithic sides, if reinforcing rods are inserted, they become beams and may be supported only at each end if desired, instead of throughout their full length as when placed in the ground. It is exactly the same with the steps and hence in order to build a flight of steps which will be open underneath it is only necessary to reinforce the steps by rods near their bottoms which extend into the strings on each side, and in turn reinforce these strings by rods carried near their bottoms from support to support. By referring to the table on page 65, it is easily determined just how thick to make the treads and how large and how many rods are required for the side strings.

PRACTICAL EXAMPLE.—For example, suppose it is desired that the flight of steps be four feet wide in the clear and each tread eight inches

broad. It is very possible that three persons may want to stand on each one of the steps at the same time, in the case of some special gathering. The average weight of a person may be considered 175 pounds. Three persons will then weigh 525 pounds. This load is to be placed on a strip only eight inches wide. For a strip twelve inches wide (for which standard width the table is computed), half as much more weight would be carried. One and a half times 525 is 788 pounds. This load is to be placed on a step four feet long so that the actual load per foot will be one fourth of 788 or 197 pounds. The table shows that for a load of 200 pounds per foot, a three inch slab can be 4.3 feet long, while a two and a half inch slab can be but 3.4 feet long. A three inch slab should be used in this case and the risers can readily be made the same thickness. Each tread and riser will weigh fifty pounds per running foot so that this weight must be added to that of the people who may stand on each step if one wishes to find how much the load will be on the side strings. Fifty pounds per foot and four feet long will give a total weight of the concrete of 200 pounds. This added to 525 gives 725 pounds per step. This total is carried equally by each string so that 362 pounds may be considered as the load per step to be carried by each string. To find the total load per foot length of string, multiply this number by the number of steps and divide by the length of the string in feet. Suppose for example there are to be ten steps, each with a six inch rise. The distance along the tread from step to step will then be ten inches. This can be easily found by making a full size drawing of one step and riser, and measuring the distance on the drawing, or it can be found by computation by squaring the height of rise (6x6=36), adding to it the square of the width of tread (8x8=64) giving 36+64=100, and finding the number which squared equals this number (10x10=100). Ten steps at 10 inches give 100 inches or 8 feet, 4 inches for the length of each string. The total load will be ten times 362 or 3620, which divided by 8 1-3 feet gives 434 pounds per foot of string. Since the string is inclined to the horizontal, something less than the full effect will be produced in the string by this load, depending on the amount of the slope.

SAFE LOAD.—To be on the safe side, however, only a slight reduction should be made if any. Since the string will not usually be more than six inches or half a foot wide (which figure will be assumed in this case), it will be necessary to double this load when making use of the table. One must calculate on some increased load which will give for a narrower width the actual amount ascertained, when this augumented load is reduced in the same proportion as the width of the actual string compared with the twelve inch standard width of the table. In this case, twelve inches is twice the width assumed so one must make use of twice 434 or 868 in using the table.

FIG. 55. REINFORCED CONCRETE SPIRAL FLYING STAIRCASE.
COURTESY OF "CEMENT."

Referring to table III it is seen that with 800 pounds per foot a beam 10 inches deep can be only 8.2 feet long, while with 900 pounds per foot a twelve inch beam can be 9.6 feet long. In this instance it would be best to make the side members of the stairs twelve inches deep and six inches wide with 2 rods $^9/_{16}$ inches in diameter in each one.

ANOTHER METHOD.—There is one other common method of designing ordinary straight flights of stairs. Instead of placing the reinforcing rods so as to carry the load from each step into the side strings which then do all the carrying, the reinforcing rods are carried at right angles to the steps and the flight is designed just as if it were made up of a series of steps one foot wide placed side by side, each narrow flight strong enough to carry all its load when supported only at the top and the bottom. The under sides of such flights are always made a smooth surface and not a series of horizontal and vertical planes. This method of design uses more concrete, but requires much less expensive form work.

ADDITIONAL CONCRETE.—The excess amount of concrete required must not be forgotten in finding the load which each little flight one foot wide has to carry, and the thickness of the slab can be considered only a very little greater in depth than the distance from the inner corner of the step through to the under side of the flight. In order to find the extra weight of concrete to be added to the weight of the persons, it is necessary to multiply together the height of rise and the width of tread (each measured in inches), and divide by two. This will give $6x8=48$, $48 \div 2=24$ pounds per foot width which must be added for each step in the example above. The weight of the persons was assumed at $3x175=525$ pounds on a four foot step or $525 \div 4=131$ pounds per foot width of flight. To this is to be added the 24 pounds extra weight of concrete making $131+24=155$ pounds for each step one foot wide. It was also found that the distance from step to step was ten inches so that the weight per inch is 15.5 pounds and for a foot or twelve inches, it is $12x15.5=186$ pounds.

WEIGHT TO BE CARRIED.—Now turning to the table it is seen that a span of 8.2 feet is satisfactory for a slab five inches thick to carry 150 pounds per foot while a five and a half inch slab will carry 200 pounds per foot. For most slopes of stairs a five inch thickness would be found all right if $^3/_8$ in. rods spaced $3\frac{1}{2}$ in. apart were used close to the lower surface of the flight each foot in its width. In the case of the stairs of the latter variety no side strings are needed, although they are often put in place simply for sake of appearance. Very complicated and interesting stair work is often erected in reinforced concrete, as is seen in the illustration of Fig. 55.

Fig. 56. CONCRETE BARN STAIRS.

Fig. 57. CONCRETE STAIRS TO BOAT LANDING.

Fig. 58. CONCRETE STAIRS IN WESTINGHOUSE LAMP CO. BUILDING BUILT ENTIRELY OF DRAGON CEMENT.

Fig. 59. CONCRETE STAIRS LEADING TO CEMENT HOUSE.

Fig. 56 shows the interior of a concrete barn, and particularly the stairs leading to the loft. They were designed without side strings according to the last method mentioned.

Fig. 57 shows a very effective boat landing with a flight of steps leading down to it. This flight is built of mass concrete directly in place.

The flying stairs in the Westinghouse Lamp Co. Building are illustrated in Fig. 58. They show how light appearing it is possible to construct a flight of high concrete stairs.

Fig. 59 shows the concrete steps and approaches leading to a cement house of excellent design. Note also the small culvert over the street gutter.

Note the open flights of porch steps in Fig. 61 and also the posts and how the iron railings are utilized in connection with the porch wall to lighten the effect.

Fig. 62 shows a flight of steps built of separate molded blocks.

STEPPING BLOCK.—A horse block of any desired size and design can be constructed by building a form box, plastered inside with a half inch of 1:2 mortar and filled in with concrete well tamped. As soon as the forms are removed, the surface of the stepping block should be carefully grouted and troweled, rounding all edges so as to prevent chipping, just as described for curbs and steps.

Fig. 61. OPEN CONCRETE STEPS AND PORCH PLATFORM.

Fig. 62. Cement Steps and Sides, Porch Supports and Balcony Railing Built of Separately Moulded Blocks.

CULVERTS.

CULVERTS under roads can be constructed either with a flat or an arched top. In the first case, it is simply necessary to build two parallel walls to form the sides of the culvert. These should be at least twelve inches wide on the top and bottom. They should be built with a vertical face on the inside of the culvert, while the faces next the earth should be sloped from the top to the bottom. The excavation should be carried so deep that the bottom of the wall is below frost line. The forms for these walls can be built exactly as described for walls in which both faces are vertical except that the uprights for the sides next the earth are to be given the desired slope. For culvert walls, where none of the wall is to be visible or subject to the action of weather, wire can be used for tying together the forms with excellent results.

BEST METHOD.—The concrete of the top of the wall should be left very rough so that the concrete for the slab will secure a firm connection with it. An excellent method of securing this result is by imbedding in the soft concrete of the walls, sharp stones extending up above the top of the fresh concrete about one-half the thickness of the concrete slab which will span the space between the walls and form the top of the culvert. The thickness of this slab will depend upon the span, the amount of earth to be filled over the top of the concrete up to the road surface, and the possible loads which may chance to come upon the road such as steam rollers, traction engines and so forth. These items and the required thickness of slab and the amount of reinforcement can be ascertained from information and tables, pages 65 and 66. The forms for the bottom of the slab can be constructed of any rough boards simply blocked up on cross pieces supported on uprights. The latter should rest on footing planks of ample size laid on the ground so that no settling will take place due to the wet concrete deposited for the culvert cover. Sometimes, where it is not an easy matter to support the uprights from the ground below, heavy cross supports are placed in recesses molded in the side walls close to their tops. When this arrangement is resorted to it is necessary to cut out each cross piece in order to remove the centering.

SEMI-CIRCULAR CULVERTS.—Semi-circular tops are often employed where the span is not too great. In order to make this shape of culvert, the cross section should be laid out upon a level space like an open floor By driving a nail in the floor at any point, tying one end of a string to this nail and by having a piece of chalk tied to the other end at a distance from the nail equal to one-half the span of the culvert, the semi-circle can be drawn upon the floor to represent the inside of the water way through the culvert. Pieces of 1 inch board 8 or 10 inches wide should then be laid so as to cover this mark, and a new curve drawn on the boards like the one on the floor. The board should then be cut on the curve so as to form several short lengths, which when put together will form a frame which will fit on the inside of the curve. Enough extra pieces should be made in the same manner so that they may be nailed over the joints of the original set to make a stiff frame. The latter should also be braced by pieces nailed across the widest point of the frame with a vertical from the center of this cross piece to the top of the frame, and perhaps a diagonal piece or two extra for bracing.

Fig. 63. SMALL CONCRETE CULVERTS.

WOODEN FRAMES.—Frames similar to that described above should be made so that they can be placed not over 3 feet apart through the culvert. These frames should be supported in place by uprights, and braced in position, after which narrow cleats should be nailed across all the frames like the staves of a barrel. These cleats should be bevelled on their edges so as to fit tightly, and if necessary the completed semi-circular box should have the exterior planed to make a smooth cylinder. Where such a semi-circular form is used, if its span is over 3 feet, special steel reinforcement should be provided and designed by a competent engineer. Where the span is small, the concrete should be carefully placed between the semi-circular form above described and outside rough boards placed in position against which the earth can be piled temporarily. The concrete at no point should be less than six inches thick and the thickness of the walls should be increased one foot over the dimensions given above where flat slabs are to be used for the culvert covers.

Fig. 63 shows on a small scale two varieties of concrete culverts. One has an arch form somewhat like that described above while the one in the distance consists simply of cement pipe molded in place with end walls and a regular sidewalk wearing surface, laid on well tamped earth.

REINFORCED CONCRETE FENCE POSTS.

Extract from U. S. Department of Agriculture.
Bulletin No. 235

This Bulletin can be secured by applying to the Secretary of the Department of Agriculture direct or can be obtained through any Congressman.

THERE is a constantly increasing demand for some form of fence post which is not subject to decay. The life of wooden posts is very limited, and the scarcity of suitable timber in many localities has made it imperative to find a substitute. A fence post, to prove thoroughly satisfactory, must fulfil three conditions: (1) It must be obtainable at a reasonable cost; (2) it must possess sufficient strength to meet the demands of general farm use; (3) it must not be subject to decay, and must be able to withstand successfully the effects of water, frost and fire. Although iron posts of various designs are frequently used for ornamental purposes, their adoption for general farm use is prohibited by their excessive cost. Then, too, iron posts exposed to the weather are subject to corrosion, to prevent which necessitates repainting from time to time, and this item will entail considerable expense in cases where a large number of posts are to be used.

At the present time the material which seems most nearly to meet these requirements is reinforced concrete. The idea of constructing fence posts of concrete reinforced with iron or steel is by no means a new one, but on the contrary, such posts have been experimented with for years, and a great number of patents have been issued covering many of the possible forms of reinforcement. It is frequently stated that a reinforced concrete post can be made and put in the ground for the same price as a wooden post. Of course this will depend in any locality upon the relative value of wood and the various materials which go to make up the concrete post, but in the great majority of cases, wood will prove the cheaper material in regard to first cost. On the other hand, a concrete post will last indefinitely, its strength increasing with age, whereas the wooden post must be replaced at short intervals, probably making it more expensive in the long run.

In regard to strength, it must be borne in mind that it is not practicable to make plain concrete fence posts as strong as wooden posts of the same size; but since wooden posts, as a rule, are many times stronger than is necessary, this difference in strength should not condemn the use of reinforced concrete for this purpose. Moreover, strength in many cases is of little importance, the fence being used only as a dividing line, and in such cases small concrete posts

provide ample strength and present a very uniform and neat appearance. In any case, to enable concrete posts to withstand the loads they are called upon to carry, sufficient strength may be secured by means of reinforcement, and where great strength is required this may be obtained by using a larger post with a greater proportion of metal and well braced, as is usual in such cases. In point of durability, concrete is unsurpassed by any material of construction. It offers a perfect protection to the metal reinforcement and is not itself affected by exposure, so that a post constructed of concrete reinforced with steel will last indefinitely and require no attention in the way of repairs.

REINFORCEMENT.—No form of wooden reinforcement either on the surface or within the post, can be recommended. If on the surface the wood will soon decay, and if a wooden core is used, it will in all probability swell by the absorption of moisture and crack the post. The use of galvanized wire is sometimes advocated, but if the post is properly constructed and good concrete used this precaution against rust will be unnecessary, since it has been fully demonstrated by repeated tests that concrete protects steel perfectly against rust. If plain, smooth wire or rods are used for reinforcement they should be bent over at the ends or looped to prevent slipping in the concrete. Twisted fence wire may usually be obtained at a reasonable cost and is very well suited for this purpose. Barbed wire has been proposed and is sometimes used, although the barbs make it extremely difficult to handle. For the sake of economy the smallest amount of metal consistent with the desired strength must be used, and this requirement makes it necessary to place the reinforcement near the surface, where its strength is utilized to greatest advantage, with only enough concrete on the outside to form a protective covering. A reinforcing member in each corner of the post is probably the most efficient arrangement.

CONCRETE MIXTURE.—The concrete should be made with Portland cement in about the proportions 1 : 2½ : 5, broken stone or gravel under one-half inch being used. In cases where the aggregate contains pieces smaller than one-fourth inch, less sand may be used, and in some cases it may be omitted altogether. A mixture of medium consistency is recommended on the ground that it fills the molds better, and with less tamping than if mixed quite dry.

WOODEN MOLDS.—Economy points to the use of a tapering post, which, fortunately, offers no difficulties in the way of molding. All things considered, wooden molds will be found most suitable. They can be easily, and quickly made in any desired size and form. Posts may be molded either in a vertical or horizontal position, the latter being the simpler and better method. If molded vertically a wet mixture is necessary, requiring a longer

time to set, with the consequent delay in removing the molds. Fig. 64 shows a simpler mold, which has a capacity of four posts, but larger molds could easily be made on the same principle. It consists of two end pieces (a) carrying lugs (b) between which are inserted strips (c). The several parts are held together with hooks and eyes. To prevent any bulging of the side strips, they are braced as illustrated. Dressed lumber at least 1 inch thick, and preferably 1½ inches, should be used. The post measures 6 by 6 inches at the bottom, 6 by 3 inches at the top, and 7 feet in length, having two parallel sides.

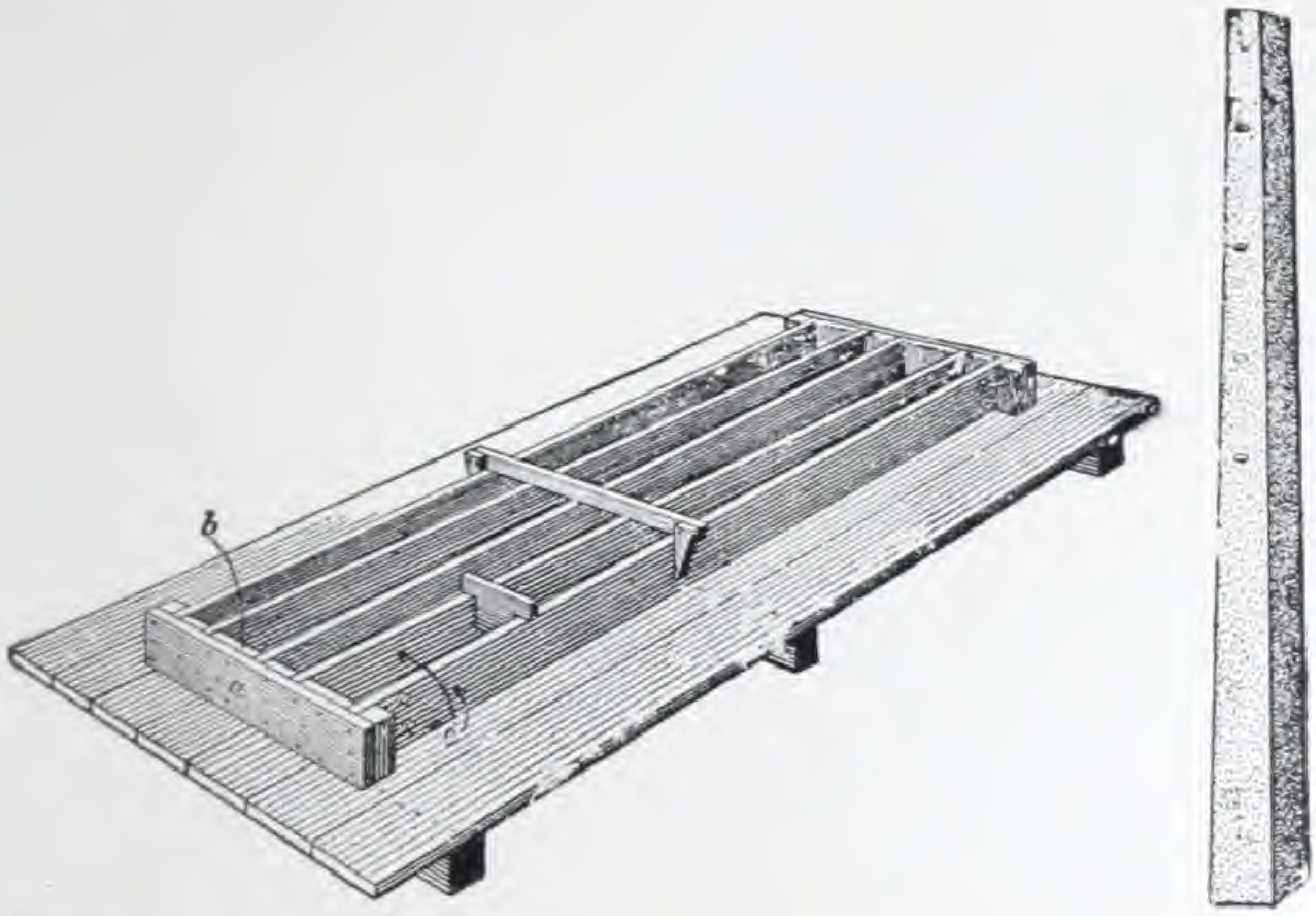


Fig. 64

If it is desired to have the posts square at both ends the mold must be arranged as in Fig. 65. This latter form of post is not as strong as the former, but requires less concrete in its construction. Great care in tamping is necessary to insure the corners of the mold being well filled, and if this detail is not carefully watched, the metal being exposed in places, will be subject to rust.

ATTACHING FENCE WIRES.—Various devices have been suggested for attaching fence wires to the posts, the object of each being to secure a simple and permanent fastener or one admitting of easy renewal at any time. Probably nothing will answer the purpose better than a long staple or bent wire well embedded in the concrete, being twisted or bent at the end to prevent extraction. Galvanized metal must be used for fasteners since they

are not protected by the concrete. A piece of small flexible wire, about 2 inches in length, threading the staple and twisted several times with a pair of pliers, holds the line wire in position.

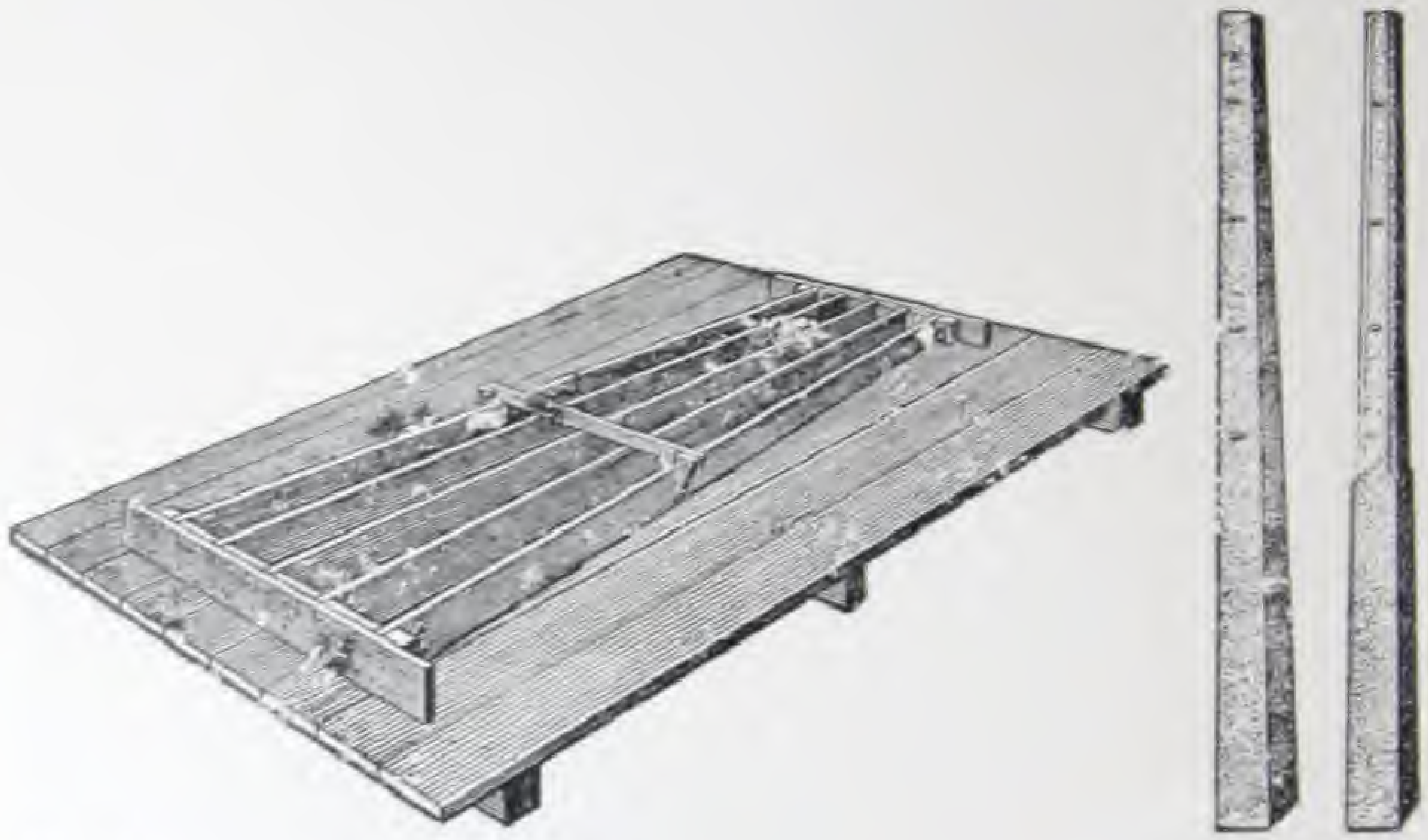


Fig. 65.

MOLDING AND CURING.—For the proper method of mixing concrete see page 13. It is recommended that only so much concrete be mixed at one time as can be used before it begins to harden. In using a mold similar to those illustrated in Figs. 64 and 65, it is necessary to provide a perfectly smooth and even platform of a size depending upon the number of posts to be molded. A cement floor if accessible may be used to advantage. The molds when in place are given a thin coating of soft soap, the platform or cement floor serving as bottom of mold being treated in same way. About 1½ inches of concrete is spread evenly over the bottom and carefully tamped

Fig. 66.

so as to reduce it to a thickness of about one inch. A piece of board cut like a scraper will be found useful in leveling off the concrete to the desired thickness before tamping. On top of this layer two reinforcing members are placed about one inch from the sides of the mold. The molds are then filled and tamped in thin layers to the level of the other two reinforcing members, the fasteners for fence wires being inserted during the operation. These reinforcing members are adjusted as were the first two, and the remaining 1 inch of concrete tamped and leveled off, thus completing the post so far as molding is concerned. To avoid sharp edges which are easily chipped, triangular strips may be placed in the bottom of the mold along the sides, and when the molds have been filled and tamped, similar strips may be inserted on top. The top edges may be beveled with a trowel or by running an edging tool having a triangular projection on its bottom, along the edges. Such a tool is shown in Fig. 66 and can easily be made of wood or metal. It is not necessary to carry the bevel below the ground line.

REMOVAL OF FORMS.—The ends and sides of the mold may be removed after twenty-four hours, but the posts should not be handled for at least one week, during which time they must be well sprinkled several times daily and protected from sun and wind. The intermediate strips may be carefully withdrawn at the end of two or three days, but it is better to leave them in place until the posts are moved. Although a post may be hard and apparently strong when one week old, it will not attain its full strength in that length of time and must be handled with the utmost care to prevent injury. Carelessness in handling green posts frequently results in the formation of fine cracks, which, though unnoticed at the time, give evidence of their presence later by the failure of the post.

TIME FOR CURING.—Posts should be allowed to cure for at least sixty days before being placed in the ground, and for this purpose it is recommended that when moved from the molding platform they be placed upon a smooth bed of moist sand and protected from the sun until thoroughly cured. During this period they should receive a thorough drenching at least once a day.

The life of the molds will depend upon the care with which they are handled. A coating of mineral oil or shellac may be used instead of soap to prevent the cement from sticking to the forms. As soon as the molds are removed they should be cleaned with a wire brush before being used again.

TOTAL EXPENSE.—The cost of reinforced concrete fence posts depends in each case upon the cost of labor and materials, and must necessarily vary in different localities. An estimate in any particular case can be

made as follows: One cubic yard of concrete will make 20 posts measuring 6 inches by 6 inches at the bottom, 6 inches by 3 inches at top, and 7 feet long, and if mixed in the proportion 1:2½:5, requires approximately—

1.16 barrels of cement at about \$2.00	\$2.32
0.44 cubic yards of sand at 75 cents	.33
0.88 cubic yards of gravel at 75 cents	.66
Cost of Materials for 1 cubic yard concrete	3.31
Concrete for one post	.17
28 feet of 0.16-inch steel wire, at 3 cents per pound .	.06
Total cost of concrete and metal for one post . .	.23

To this must be added the cost of mixing concrete, molding and handling of posts, and the cost of molds, an addition which should not in any case exceed 7 cents, making a total of 30 cents per post.

TESTS OF CONCRETE FENCE POSTS.

In the summer of 1904 a number of reinforced concrete fence posts were made for experimental purposes, by the U. S. Dept. of Agriculture, with a view to determining their adaptability for general use. These posts were made some with and some without reinforcement, and tested at the age of 90 days.

The reinforcement, ranging from 0.27 per cent. to 1.13 per cent., consisted of four round steel rods, one in each corner of each post about 1 inch from the surface, the posts having a uniform cross-section of 6 by 6 inches. The posts were molded in a horizontal position, as this was found by trial to be more satisfactory than molding them vertically.

Plain concrete was mixed moderately soft, crushed stone between one inch and one-fourth inch, and gravel under three-fourths inch being used as aggregate. River sand fairly clean and sharp, was employed with Portland cement. As would be expected, those posts which were not reinforced possessed very little strength.

The reinforcing members were placed in the corners of the posts about one inch from the surface, looped and bent. These posts were not designed with a view to developing the ultimate compressive strength of the concrete, but where greater strength is necessary it may be obtained at small expense by increasing the percentage of reinforcement. It is important that a fairly rich concrete should be used in all cases to enable the posts to stand exposure and to prevent chipping.

OBJECT OF TEST.—In these tests, the object was to determine what transverse load, applied at a point 4 feet above the ground line, would be sufficient to crack the post, as well as the maximum load which could be sustained. It was noticed that the saving in concrete introduced in the construction of these posts by making them tapered was accompanied by a marked decrease in strength as compared with the other posts similarly reinforced. It would also appear that the twisted wire has a slight advantage over the barbed wire as a reinforcing material, particularly when two wires are used in each corner of the post.

As stated above it is impracticable to make a concrete fence post as strong as a wooden post of the same size, and this is more especially true if the post has to withstand the force of a sudden blow or impact. In order to study the behavior of these posts under impact, a number of them were braced, and subjected to the blows of a 50-pound bag of gravel, suspended from above by a 9-foot rope. The first blow was delivered by deflecting the bag so as to give it a vertical drop of 1 foot, and for each successive blow the drop was increased 1 foot. None of the posts showed any sign of failure under the first blow.

Although it might appear from these results that posts as here described have hardly enough strength to recommend them for general use, it should be remembered that in many cases fence posts are not subjected to impact, and it may prove more economical to replace from time to time those which fail in this way than to use wooden posts, which being subject to decay, must all be replaced sooner or later.

Fig. 67 shows some fence posts laid out to season. Note the way in which the reinforcing rods are arranged and tied together, also the beveled edges on the portions of the posts which will be above ground and the effect of the cement wash which has been applied.

FENCE RAILS.—Besides the posts for fences, the running members can also be made of concrete, molded separately, hardened properly and blocked up in position so that when the forms for the posts are in place, and the concrete deposited in them the runners are in the final positions they are to occupy and have been firmly bedded in the concrete of the posts. If deemed preferable, the posts for this variety of fence can be molded separately in special forms arranged so as to produce recesses formed in the concrete work. This is accomplished by placing blocks at the necessary points on the sides of the orms. These recesses will serve to receive the ends of the running members of the fence and it is necessary only to tamp a post in position, set in place the strings between it and the next one, propping them so that the next post can be put in place, and then tamping the post firmly in the ground. It is often preferable under those circumstances to place a small amount of concrete in the post hole instead of refilling it with earth solely. The blocks which are placed on the sides of the forms should be made with a small taper so that, when the forms are removed, the blocks will come away easily without breaking apart the fresh concrete work. A fence made of this description is absolutely indestructible, needs no painting, will not be affected by attacks of burrowing insects and stock, and small animals will not gnaw at it or otherwise destroy it. Very ornate effects can be produced with a little care and ingenuity, as are shown in the accompanying photographs of actual work.

Fig. 68. CONCRETE FENCE BUILT OF DRAGON CEMENT.

For ordinary farm work where a large number of posts are to be molded a metal form will be found most economical. There are several such advertised and care will produce excellent results with any of them.

Fig. 68 shows a fence built of Dragon Cement Concrete on a dairy farm. The posts and runners were molded and erected as described above.

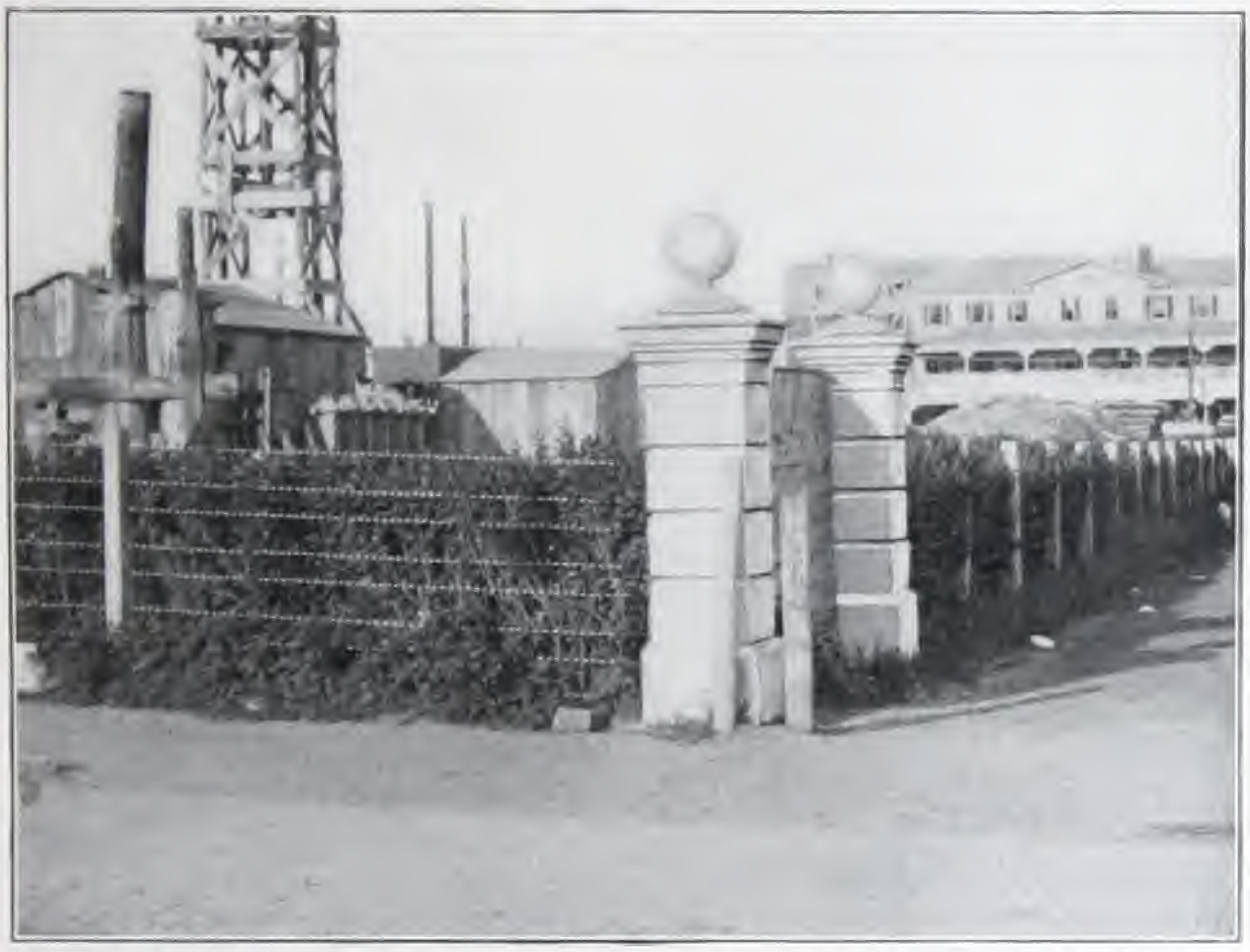


Fig. 69. CONCRETE POSTS WITH WIRE FENCING.

Fig. 69 shows a line of fence posts supporting a wire fence The wires are carried directly through each post, in small tin pipes placed in the forms before the concrete is deposited. Note also the effective gate posts molded in concrete.

In Fig. 70 is shown an excellent design for a hitching post. The Eye which holds the ring was simply inserted in the wet concrete at the proper place. Note also posts of the line fence, the cement walk and curb combined; the concrete block fence and the cement walk to the side of the house with the step leading to it.

Fig. 71 shows how a wooden fence may be fastened to concrete posts. The large gate posts of concrete are also very effective.

Fig. 70. CONCRETE HITCHING POST—LINE FENCE POSTS, WALKS AND CURB ALL OF DRAGON CEMENT.

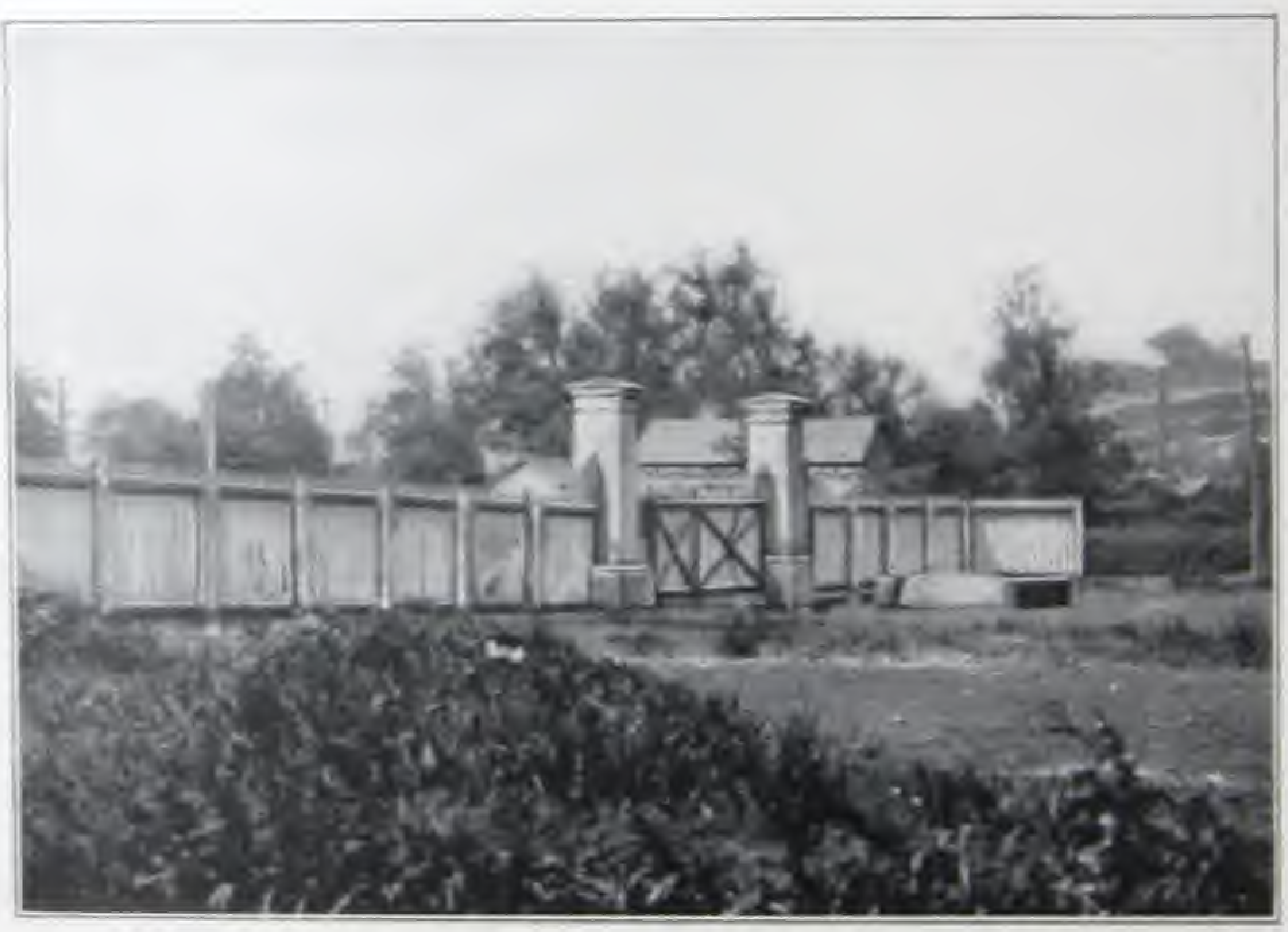


Fig. 71. WOODEN FENCE WITH CONCRETE POSTS.

Fig. 72 shows a continuous concrete fence. It was cast in sections and set up in place and held by the posts and cap. The fluted appearance was secured by using pieces of corrugated iron for the molds. Fig. 73 shows another view of another portion of the same fence. This illustrates the method used for carrying it up an incline on the top of a concrete retaining wall.

Concrete is being employed for making telegraph poles, trolley poles, electric light poles, etc. Fig. 74 shows an example of the latter variety as manufactured by a special company which makes a hollow pole.

Fig. 72. CONCRETE FENCE CAST IN SECTIONS AND SET IN PLACE.

Fig. 73. CONCRETE FENCE ON AN INCLINED RETAINING WALL.

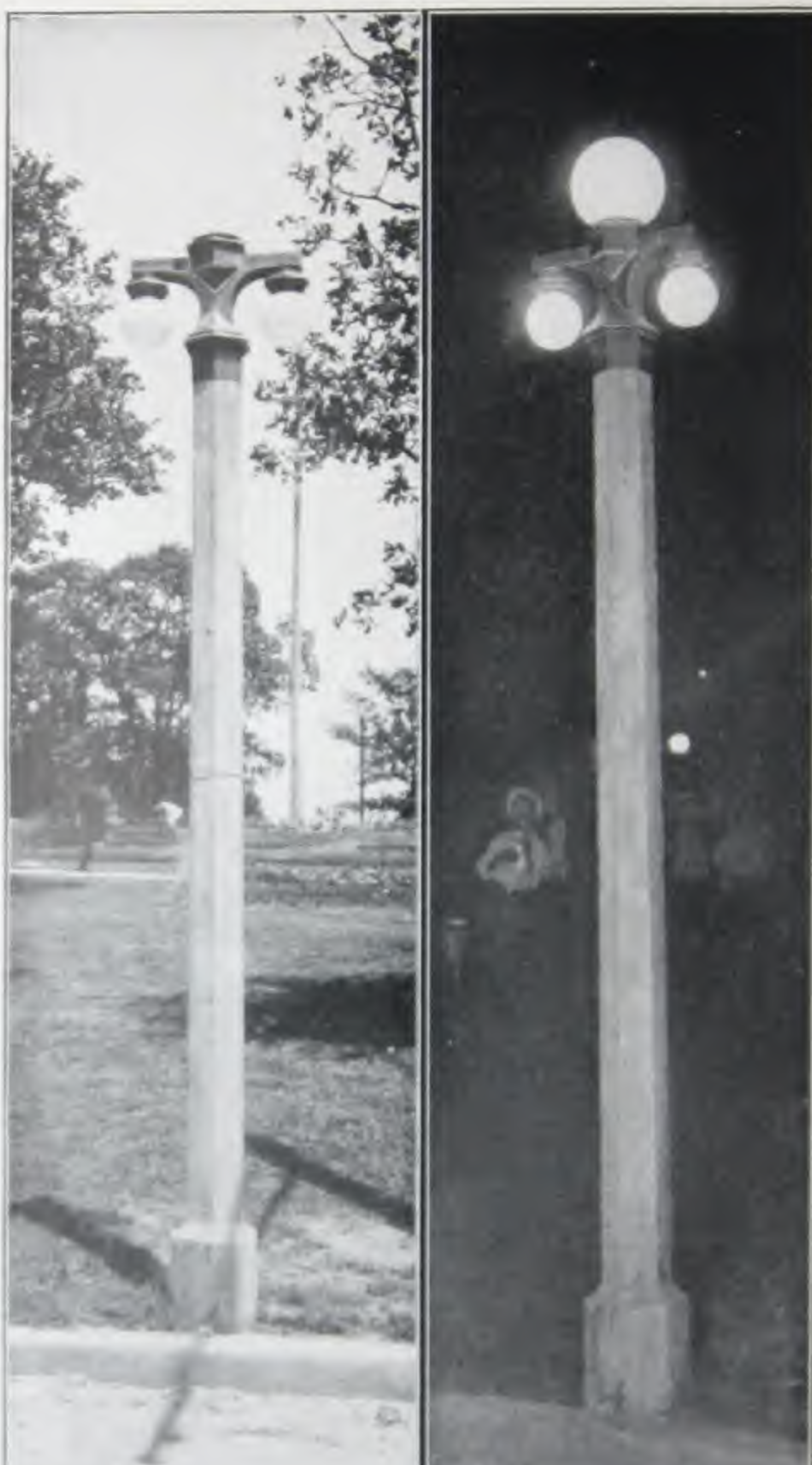


FIG. 74. CONCRETE ELECTRIC LIGHT POLE
COURTESY OF "CEMENT AND ENGINEERING NEWS."

WATERING TROUGHS.

EITHER in the field or in the stable, a watering trough is essential for the comfort of stock. If made of concrete, such a trough is indestructible, and where its first cost is found to be more than one of wood, the life of the concrete will more than make up the difference.

Troughs may be constructed with or without reinforcement, the cost being practically the same in each case, since the concrete, where not reinforced, must be about one and one-half times the thickness necessary if steel is employed. The inlet pipe may be inserted through the side or bottom of the trough and molded in place during its construction, or it may be led over the top. In either instance, an outlet pipe should be molded in near the top and led well away from the trough to prevent muddy or frozen ground in its vicinity. By the use of an automatic shut-off valve with float, such as can be secured from any plumber, the supply can be automatically regulated.

Troughs can be long and narrow, or more nearly square. They may be built close to the ground with a curb of small height around the edge, similar to a fountain basin, or they may be built two or three feet high, so that stock will not step into them.

Fig. 75. STOCK WATERING TROUGH OF CONCRETE.

In order to secure water tightness, which is essential, a concrete made in the proportions of 1:2:4, should be used wet and all placed at one operation. Even with these precautions taken, long tanks are apt to crack, unless plenty of reinforcement is put in the wall. For a large tank a special foundation should be made in a specially drained excavation, similar to that described for a fountain basin.

Fig. 76. FIELD DRINKING TROUGH.

The outside forms for the walls are easily constructed, as described under general subject of forms, page 28. In order, however, to place the concrete in a single operation, when it is so wet, it is necessary to build an inside form like a box with a tight bottom, the outside dimensions of the box corresponding with the inside dimensions of the proposed tank.

The concrete for the bottom of the trough is first to be deposited, the reinforcement if used, being installed at the proper point. Have the inner form box all ready, and as soon as the bottom concrete is in place, put the inside form upon this wet concrete, supporting and bracing it from the outside wall forms, if necessary. Before the bottom concrete has commenced to stiffen, pour in place the concrete for the walls, churning it thoroughly, so as to secure a very dense, even mass.

The forms should be left in place for several days, but, immediately on their removal, both the inside and the outside of the tank should be painted with a grout mixture of cement and water to the consistency of cream, applied with an ordinary white-wash brush. The tank should be left to harden for

a week or more, during which period it should be carefully protected from the effects of sun and wind, and should be thoroughly sprinkled each day.

A small circular trough or tank can be constructed the size of an ordinary water barrel by sawing in two an old barrel, one-half of which can then be used as the outside form. The inside form can be made just like the one for the inside of the cement pipe described on page 185. Such a trough would be small in diameter. A larger one can be made by using the half barrel as the inside form for the tank, and by building around this half barrel a mold very similar to that described for the outside form of the cement pipe above referred to.

Long, narrow troughs for small stock can be built upside down, by first erecting a triangular or other shaped mold for the inside of the trough and then placing boards against the sides of this inside form just like the side boards of a street curb, as shown in figure 50. If the tanks are more than three feet long, at least two reinforcing rods should be imbedded in the concrete, one in each side, with occasional cross-rods about two feet apart.

Fig. 77. SPRING CURB AND DRINKING BASIN OF CONCRETE.

An ordinary watering trough made with a half barrel as the inside form, should not cost more than ten dollars complete.

The drinking trough illustrated in Fig. 75 was molded of Dragon Cement Concrete at a cost of only one bag of cement and a little time with old lumber and gravel and sand on the premises. Fig. 76 shows a field drinking trough of concrete. Fig. 77 shows a spring curb and drinking basin and Fig. 78 represents a circular watering trough in the center of feeding floor.

Tanks built of concrete about the size of the one made with a half barrel, either as inside or outside form, can easily be placed on stone boats or drags, so as to be readily transported from place to place. They are then available for transporting water, fertilizer, slop, swill, etc.

Fig. 78. CEMENT TROUGH IN CENTER OF CONCRETE FLOOR.

CISTERNS.

A CISTERN is nothing but a tank placed underground with necessary inlet and outlet pipes, and supplied with a cover and some means of entering it through the top for purposes of cleaning. If the cistern is rectangular in shape the cover can be simply a concrete slab like that used for the cover of a flat culvert, and information concerning the thickness of concrete, the amount of reinforcement and so forth may be taken from the table on page 65. The side walls of a cistern can be considered either as retaining walls, which have earth on one side and sometimes water, or nothing but air on the other, or they can be designed like reinforced concrete slabs. Because of the possibility that the cistern may at times be empty and other times full, it is necessary to place reinforcement close to each vertical surface, for the tendency to bend is sometimes in one direction and sometimes in another. The thickness of wall and the amount of steel to be inserted close to each vertical surface can be obtained with sufficient accuracy by using the table on page 65 with

Fig. 80. CONCRETE SWIMMING POOL.

Fig. 81. CONCRETE WATER TANK BUILT OF DRAGON CEMENT.

the load per square foot found by multiplying 63 by one-half the maximum depth of water which the cistern can contain. These rods can be run vertical and be well tied to others extending through the concrete cover and through the concrete bottom of the cistern.

In order to have the cistern water tight, great care must be exercised in making the connection between fresh concrete and that which has been placed so long that it has begun to harden. The whole inside should be coated with a stiff grout applied with a whitewash brush exactly as described for silos. Circular cisterns can be built the same way as silos using five times as much reinforcement as there described.

Non-destructible and explosion-proof gasolene, wood alcohol and kerosene tanks can be constructed with great advantage out of concrete. This material is entirely practical for making swimming pools such as shown in Fig. 80. It is best not to try to rely on the water-tightness of the concrete itself in such large structures, but provide special means for water proofing. A large water tank is illustrated by Fig. 81, erected of reinforced concrete using Dragon Cement. The design shows what can be done for private estates on a smaller scale where such a structure is desirable.

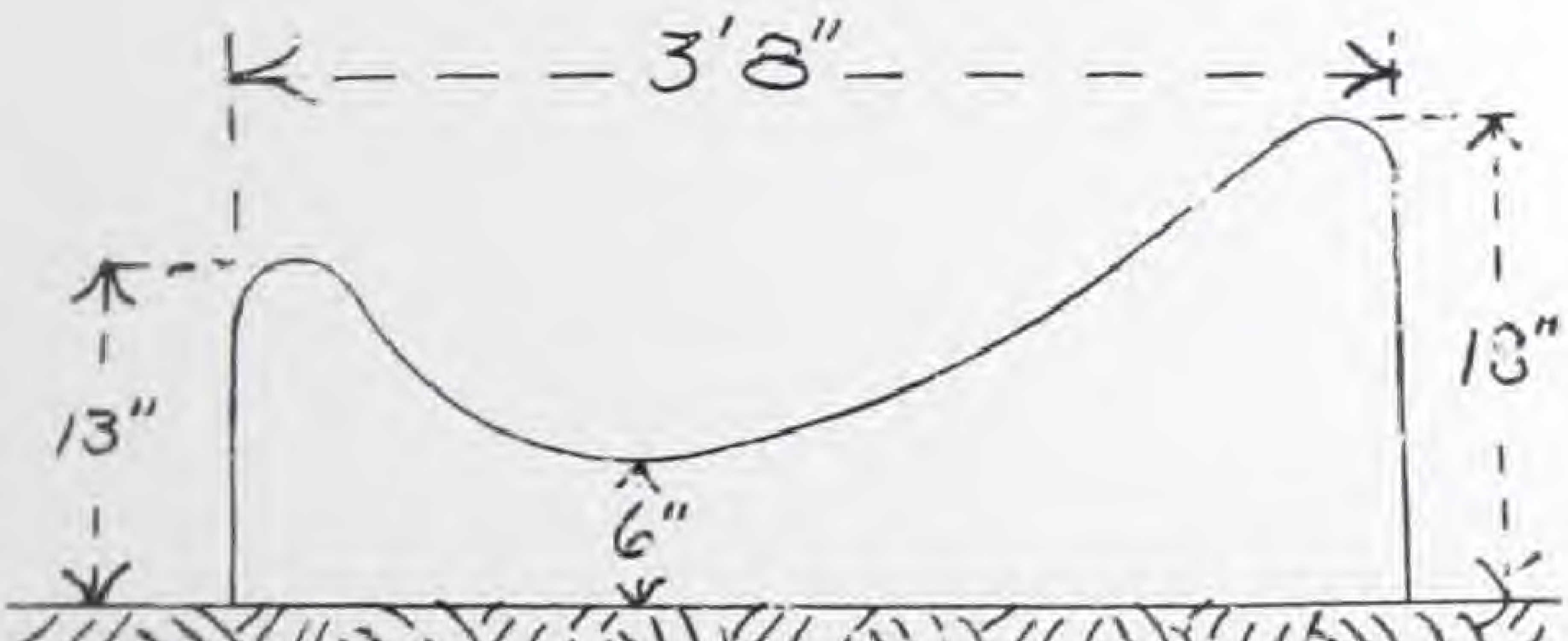


Fig. 82. Section of Cow Manger.

COW BARNS.*

THE requirements being laid down by Boards of Health, and the natural evolution which is taking place in the dairy business because of the requirements with regard to certified milk and other things, is leading more and more to the adoption of concrete for all dairy farm purposes. When, in an entirely concrete structure, floors, troughs, stalls and all other fixtures are made of that material, and properly treated and finished to prevent the absorption of moisture, hygienic conditions are realized as nearly as it is possible to obtain. In the single item, for instance, of feed troughs for the cows, there has been a considerable change. At the present time, dairy experts have practically come to the conclusion that a low, wide trough is far superior to one with high sides. The interior should be so shaped that a broom can be used to sweep the trough clean with a sidewise motion instead of washing all materials to one end, and there removing them, as is necessary with a trough with high, steep sides. The design shown in Figure 82 is recommended, as particularly good for the following reasons: (1.) The side of the trough toward the cow is so low that it does not catch the breath of the cow, but is still of such height that material is not easily spilled out to any great extent. (2.) Again the trough is of such width that the cattle will not waste much material by throwing it out on the floor. (3.) There is plenty of depth for the cattle to drink water freely, even though the total depth of the water cannot very well exceed six inches.

Such a trough as that shown in the figure contains about three and a half feet of concrete for one foot of trough, exclusive of the material contained in the floor proper. Such a trough should be given a finish similar to that of the top layer of a sidewalk. The trough is most easily constructed by setting up side boards exactly as for a concrete curb, and then cutting from a piece of metal, or several boards properly packed together, a template made in the shape of the inside of the trough. Just as for sidewalk construction, the upper edges of the side boards should be left alsolutely level and true, so that the template can be swept along on them, thereby shaping the inside of the trough. Such troughs should not cost more than seventy-five cents per running foot.

Drains laid with proper slope can be molded in the floors. For the purpose of ventilation, and to produce freedom from condensation, special walls should be made, either hollow or of such material as described in page 41, to bring about the special ends in view. Where special ventilating ducts are required, they can be installed directly in the

*Much of the information contained in this chapter was obtained through the courtesy of Messrs. S. L. STEWART and HANS HILTON, Dairy Experts.

Fig. 84. REINFORCED CONCRETE COW BARN AT GEDNEY FARMS, WHITE PLAINS, N. Y. CONSTRUCTED OF "DRAGON" PORTLAND CEMENT

concrete walls, either by molding into them terra cotta tile or flue linings, or by making use of galvanized pipes of proper size. In stables for horses, cattle, hogs, or other stock, a perfect ventilation system is essential. Such ventilating flues should be carried to chimneys which extend above the roofs both of the special structure involved and of adjoining ones.

Fig. 83 shows a concrete manger in a concrete cow stable. Note the concrete tank at the end of the manger with the faucet for running water into the manger.

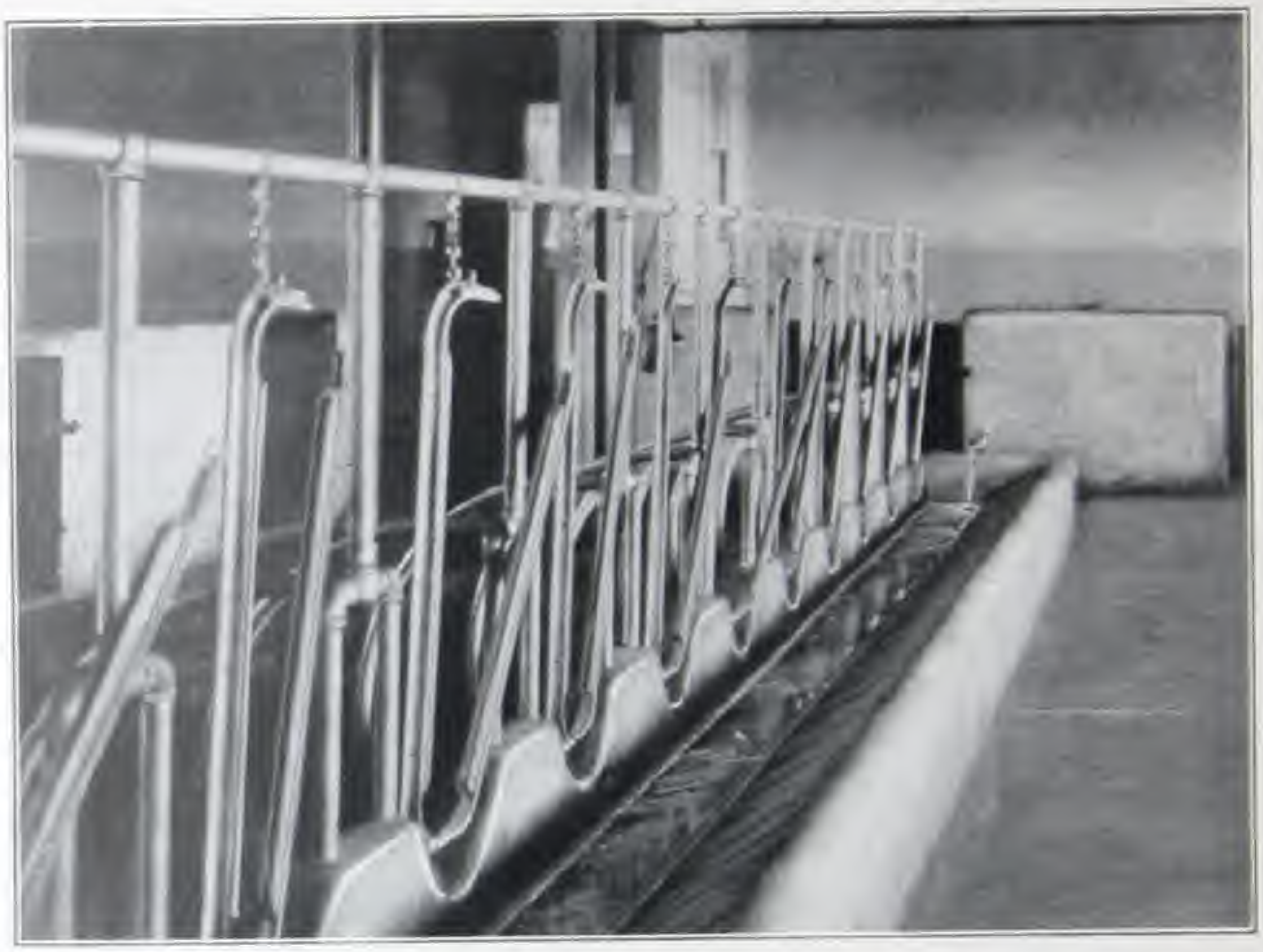


Fig. 83. INTERIOR OF CONCRETE COW BARN

Mr. Charles Gurney, of Red Cloud, Nebraska, is quoted as saying: "The time is coming when cement will be the universal building material on the farm. A concrete wall and floor eliminate the rodent and most vermin, and in a few years, a well constructed building, with bin attachments, will save enough grain to pay for the cost of construction.

In extreme cold weather, such a building affords an even temperature for live stock. I never have to worry about my young stock on a cold night. Another advantage is the cleanliness. I have no tuberculosis among my cattle, no cholera hogs and no roup in the chickens."

Fig. 84 shows a large concrete cow barn on a well known dairy farm, several of the buildings of which were built of Dragon Cement.

DAIRIES.

THE DAIRY is simply an ordinary box-like building with a few special features adapting it for special uses involved, namely: the receiving room, wash room, bottling room, the refrigerator, cold store room, the shower baths, closets, etc. Tanks similar to those already described can be erected for washing purposes, while all that is required for ice houses, cold store rooms, refrigerators, etc., is the construction of concrete walls with one or more hollow spaces for insulating purposes. The larger number of air spaces that exist, the less will be the loss from melting of ice.

Fig. 85 shows the exterior of a dairy building under construction. It is an excellent example of modest farm building architecture. Note especially the ample ventilating stacks.

Fig. 86 shows a concrete washing trough with its two compartments and washing machine between.

Fig. 87 shows the interior of a bottling room and demonstrates its perfect sanitary condition.

Fig. 88 shows another dairy building, one wing of which is devoted to ice storage. Note the double doors to the ice house, and also the numerous ventilating stacks.

Fig. 85. CONCRETE DAIRY BUILDING.

Fig. 86. CONCRETE WASHING TROUGH IN SANITARY DAIRY.

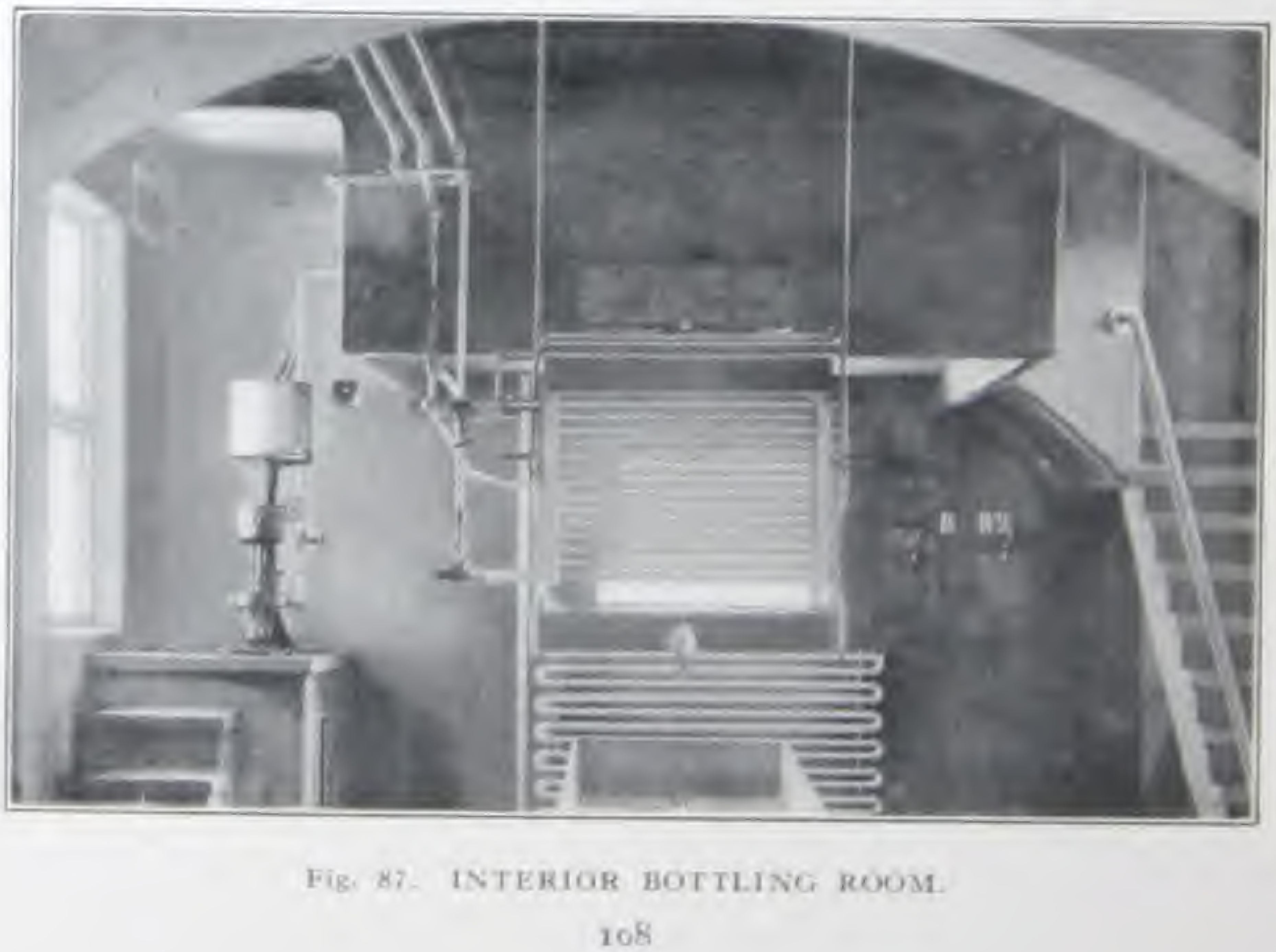


Fig. 87. INTERIOR BOTTLING ROOM.

Fig. 88. CONCRETE DAIRY WITH ICE HOUSE ANNEX.

HORSE STABLES.

THERE is no more serviceable use for ideal concrete construction than in the building of permanent stables for the intelligent horse. There is no domesticated animal more likely to be benefitted by such a sanitary structure. Some of the finest out-buildings of this character are now seen in many places on farms and in towns, and are illustrated in this book

Fig. 89. CONCRETE BLOCK STABLE.

Fig. 89 shows the exterior of an excellent example of cement block architecture applied to a stable. Note especially the artistic molding of the small door and window lintels in the front. Dragon Cement was used throughout.

Fig. 90 shows a stable, hay barn, and wagon shed lean-to, all erected of Dragon Cement Concrete. For simple effective work nothing can be better than such buildings on the farm.

A much more pretentious stable and wagon house will be seen in Fig. 91.

Fig. 90. MONOLITHIC CONCRETE STABLE, BARN AND SHED

Fig 91. LARGE CONCRETE STABLE.

Fig. 92 shows the interior of a stable where the stall partitions were made of a heavy plaster coat applied on each side of metal lath held in place by the pipe supports. In this instance the floor on which the horses stand consists of separate oak timbers which can be easily reversed and turned

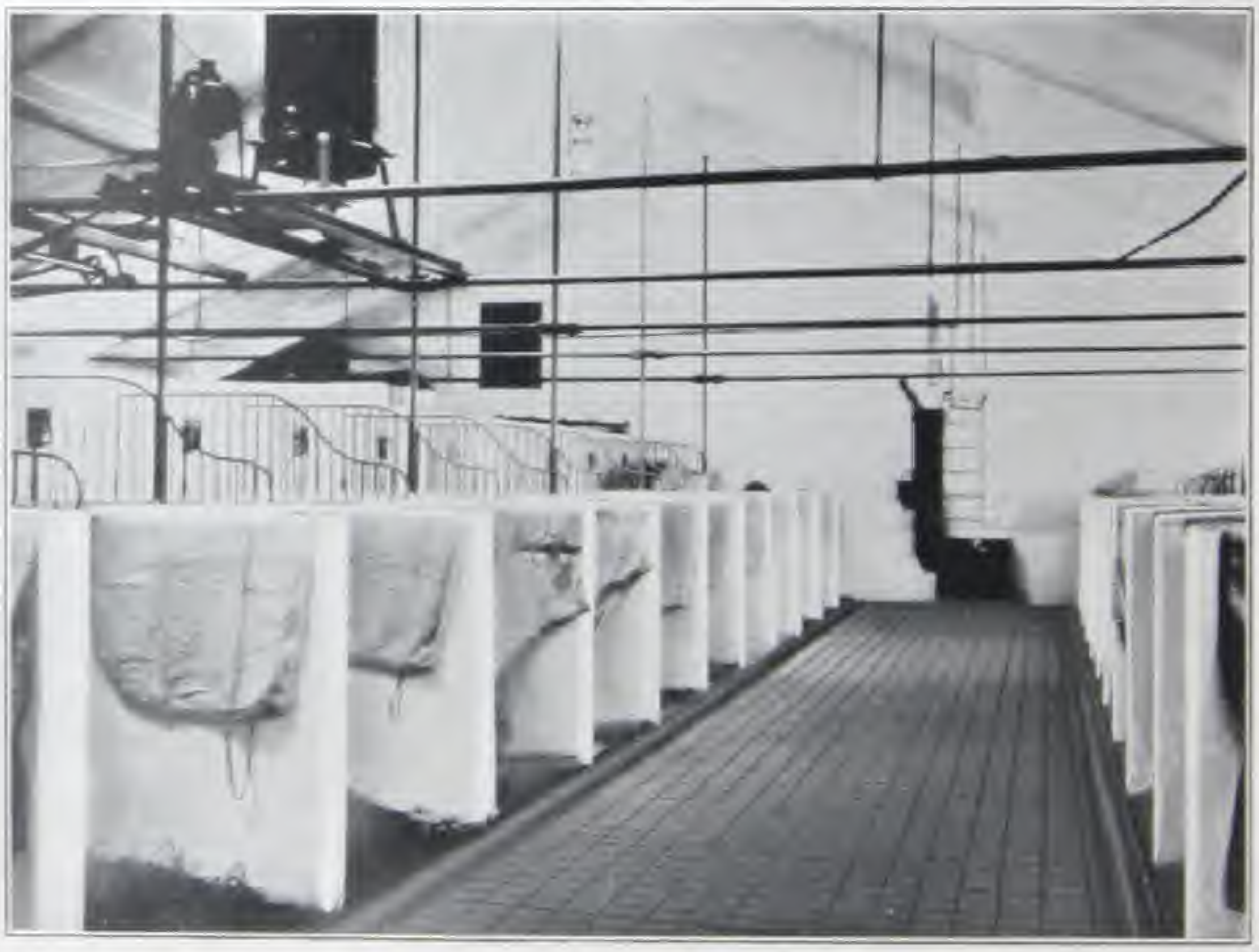


Fig. 93. SOLID CONCRETE STALLS.

over so as to get the maximum of wear from them. They are also readily removed for purposes of cleaning. A drain is located just inside the projecting ends. It is visible in the distance on the right side of the runway.

Another design of stall partition is shown in Fig. 93. Here it is made of 4 inches of solid concrete. Note also the open drain and the close boarding on the stall floor. Stables built of concrete and fitted with concrete partitions are certain to be cooler in summer and warmer in winter than wooden structures, and are therefore of very great benefit to the animals.

CONCRETE FARM BUILDINGS WITH SHIPPING PLATFORMS AND CONCRETE PAVEMENT IN YARD OFTEN USED FOR A FEEDING FLOOR.

POULTRY HOUSES, ETC.

CONCRETE is very useful in the construction of buildings for the housing accommodation of poultry. They are very readily cleaned, are not apt to become infested with vermin, are warm in winter and cool in summer, are proof against rats and similar pests and are reasonably cheap.

Water and feeding pans can be molded directly in the work,—also the perches. Nesting boxes of cement may be built which can be completely renovated as often as necessary. With all-cement construction it is possible to burn out each nest or the whole nesting house whenever needed, afterward applying a coat of whitewash, for purging it of all vermin. An enclosed scratching floor can be easily constructed for winter use by laying a good cement floor in a concrete building, spreading over it six or eight inches of clean sand, cinders or gravel and over this a layer of straw.

For the health of the poultry, nests should be enclosed except on one side and all walls and roof should be made of such material as to prevent the appearance of condensation. The table of page 65 will give the proper thickness, etc., for roof slabs, and as for all other buildings of a permanent character, the footings must be carried down below frost line.

Fig. 94 shows a poultry house with an improvised scratching shed between it and a concrete barn, and Fig. 95 is a nearer view of the same.

Fig. 94. CONCRETE POULTRY HOUSE AND BARN.

Fig. 95. CONCRETE POULTRY HOUSE.

Fig. 96. CONCRETE POULTRY HOUSE COSTING $9.00.

The chicken house shown in Fig. 96 was erected during the spare hours of the owner. Its total cost aside from his time was $9.00.

Fig. 97 shows a concrete nest like those above described which is being used as a brooder. Note how the earth is heaped up to the entrance to the nest so that the young chicks can reach it. One of the chicks is to be seen just inside the nest at the left of the hen.

Fig. 97. CONCRETE HENS NEST.
COURTESY OF B. M. BANGS & CO.

Fig. 98 shows a tool house elevated on concrete columns so that the space beneath is used for wagon storage. The whole structure was built of Dragon cement. Note the broadening of the columns at their bases to form wheel guards so that the hubs will not chip off the columns, if hit.

Such an arrangement as that shown in the above figure is an excellent one for corn cribs and grain bins, they being thus located where rats cannot make depredations.

In Fig. 99 is shown a concrete top or roof placed on an old out-door-cellar used for the storage of vegetables, and is a good example of how this material can be adapted to repair time-worn structures.

A concrete tunnel or passage way between two main buildings of a large institution is represented by Fig. 100. This tunnel is used for a thoroughfare and for placing of gas pipes, water mains, electric and telephone wires, etc.

Fig. 98. CONCRETE TOOL HOUSE AND WAGON STORAGE.

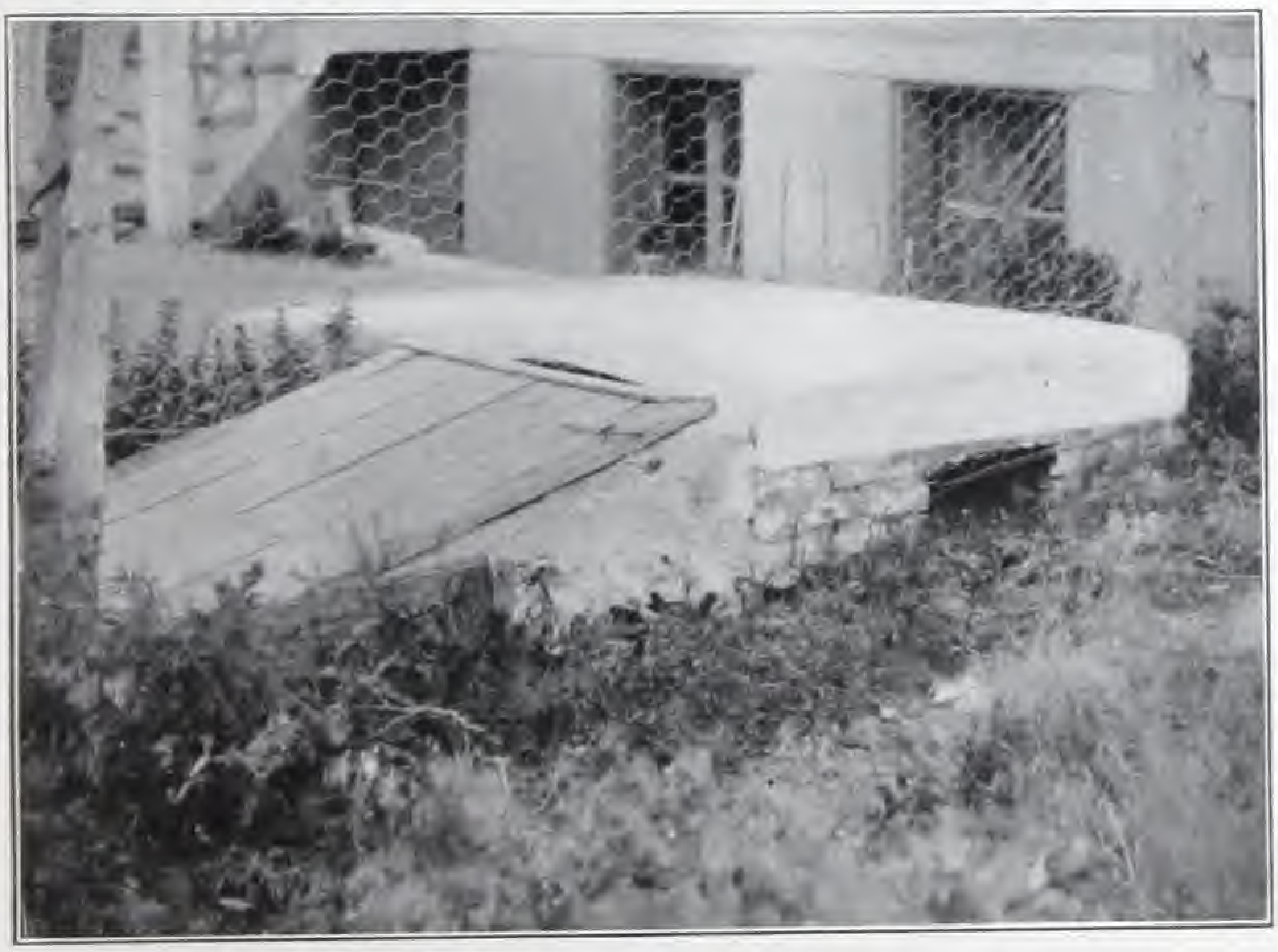


Fig. 99. CONCRETE TOP ON OLD VEGETABLE CELLAR.

Fig. 100. CONCRETE TUNNEL BETWEEN BUILDINGS.

CONCRETE SILOS.

TAKEN IN PART FROM BULLETIN NO. 21 OF THE ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS AND FROM VARIOUS BULLETINS OF THE U. S. DEPT. OF AGRICULTURE.

WHAT SILOS ARE.

A SILO is a tank in which fodder may be placed and preserved in a green state for feeding stock at times when a natural green pasture is not available. By the use of silos the fodder is "canned," very much as a housewife cans or preserves fruit and vegetables.

Round silos are the best. The amount of building material required to construct a silo of a given capacity is less for a cylindrical shape than for any other form. The crop is also best preserved in such a silo, as this form renders packing easy.

As a preserve-can must be air-tight to prevent the fruit from "working," for the same reason must the silo be air-tight. The air which is necessarily confined in packing, causes the silage to ferment, but if no additional air gets in, the silage keeps perfectly. If the air does get in, the silage molds, and cattle will not eat it.

KEEP AIR-TIGHT.—No building material can be made as air-tight as concrete. Builders of other kinds of silos recognize this fact, and recommend a coating of cement on the inside "to keep the silo air-tight." Most silos are used for about six months, during the winter, and the remainder of the year are empty. Wooden silos are like wooden tanks or buckets. When allowed to stand empty they shrink, the joints open, they leak; the once air-tight silo, tank or bucket becoming a sieve. Coating on the inside with cement prevents this for about one year, when the shrinkage is repeated, and this time the cement lining cracks and again the silo becomes a sieve. In order to keep it air-tight in this way, the cement coating has to be replaced every year.

The acids formed by the slight fermentation in the silage, caused by the air left between the corn-stalk in packing, rot out wood and eat away metal silos. The alternate wetting and drying which every silo receives also rots the wood and rusts the iron. These acids have no effect on concrete.

Every farmer knows the annoyance and danger to be experienced from rats. Nothing built of wood is rat-proof, and a wooden silo makes a fine nesting-place. Air is also admitted to the silage through the rat-holes; this being well known, all companies building silos recommend a concrete floor to keep out rats. A concrete silo, properly built, is air-tight. It does not shrink in the hot, dry weather. It does not swell up in damp weather. The moisture going in with the silage should be kept in. This keeps the silage from "dry Firing." A concrete silo is not only air-tight, but water-tight.

Silage settles after being packed, and even the slightest roughness is liable to catch the corn-stalks and prevent their settling evenly. The silage around the air-space formed in this way becomes moldy and must be thrown away. Concrete silos, when built with surfaced boards for inside forms, are smooth, and while it is well to place a wash upon the inside, this never has to be replaced.

A silo built entirely of concrete is absolutely vermin-proof.

FIRE-PROOF.—Fire is the farmers' greatest dread. When a fire starts from lightning or any other cause, the farm buildings usually burn down. For this reason, insurance rates are very high, and farmers find it a great tax to protect themselves by carrying insurance. The buildings, however, are not the most serious loss; fires most often occur during the latter part of the summer or early fall after the crops have been harvested, and while the buildings can be replaced, practically the year's work of the farmer is gone. Very often the fire spreads so rapidly that the stock is also lost.

A concrete silo cannot burn down, as concrete is fire-proof; nor can the food stored in it be either injured or destroyed. A temporary structure can be erected to replace the burned building but the crops cannot be replaced except at great expense. Insurance companies have recognized the indestructible qualities of concrete by making an insurance rate so low as to be within the means of every farmer. The only real objection that has ever been made to a concrete silo is its cost. The cost varies owing to the price of materials of which the concrete is made. In many places concrete silos are cheaper than any other kind. Few farmers are without a gravel-pit suitable to furnish both gravel and sand of a quality proper for making good concrete.

THREE KINDS OF CONCRETE SILOS.—They have been in use several years and are known as Monolithic Concrete Silos (or solid wall silos), the Hollow Wall Monolithic Concrete Silos, and Concrete Block Silos. All three are good, and in choosing between them, the cost (which is fixed by local conditions), should be the deciding feature, unless the location of the farm is so far north that the extreme cold in winter makes a hollow monolithic wall or hollow block wall silo preferable, to prevent freezing.

1. The monolithic concrete silo is cheap, easily built, and fulfills all the requirements of a perfect silo. This type has been extensively used. They were first built with very thick walls, and without steel reinforcement. By using steel reinforcement, a greater strength can be obtained with a much thinner wall. This saves in the quantity of concrete used, and also in the cost of material and labor. In Fig. 101 is seen the representation of monolithic reinforced concrete silos under construction in which Dragon cement was used.

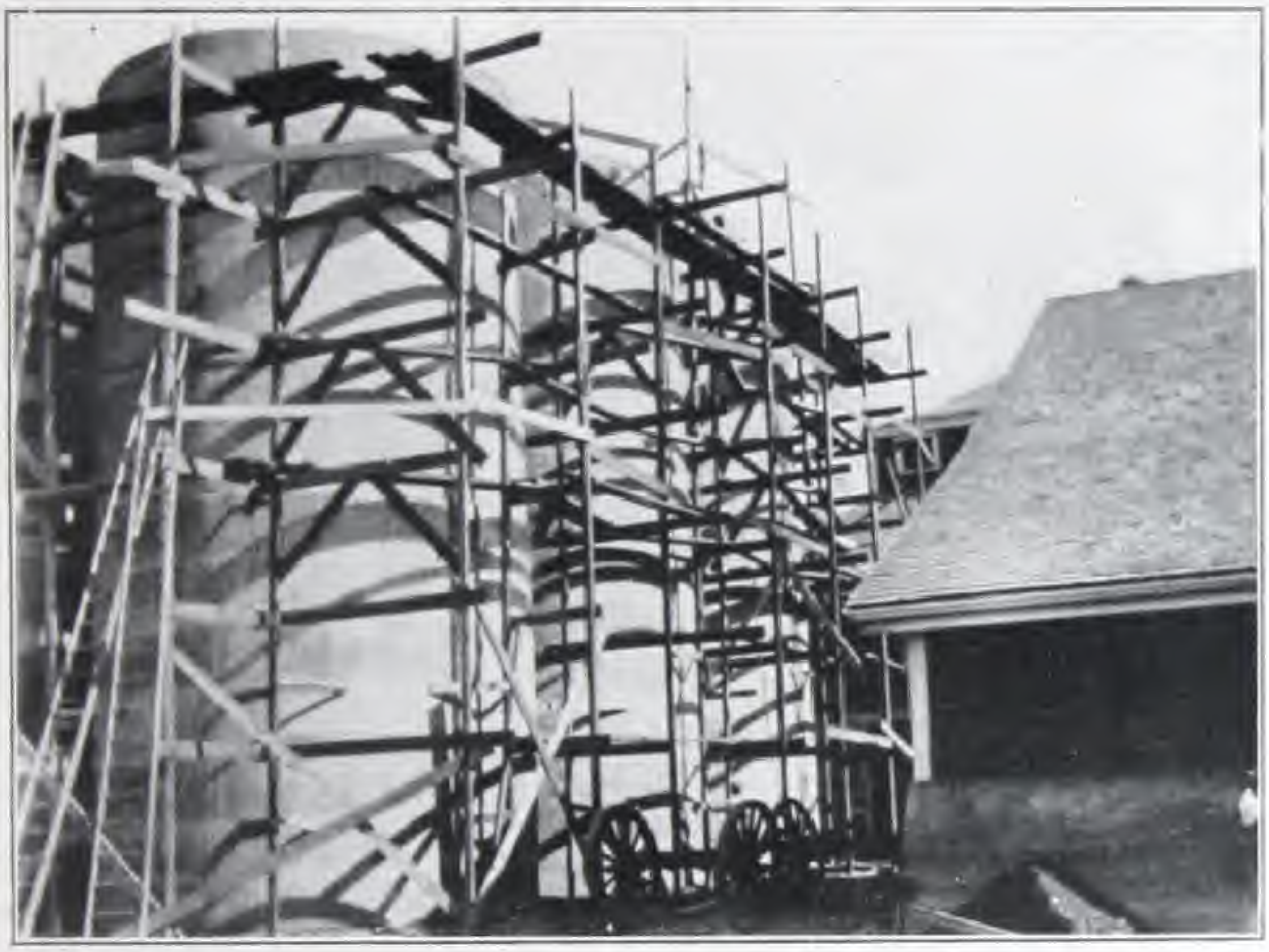


Fig. 101. THREE MONOLITHIC REINFORCED SILOS.

2. The hollow wall monolithic concrete silo is constructed much the same as the solid wall, except that two walls are built instead of one, with a hollow air-space of about 4 inches between them. The inner wall is reinforced in the same way as in a single solid wall silo. The only reason for the outer wall is to form the air-space between the walls. This keeps the silage from freezing. The labor and time lost in thawing out the silage is usually saved by the use of a hollow wall silo. This is quite an item in districts where the silage would remain frozen for two months or longer. The cost of the hollow wall silo is about one-fourth greater than the solid wall silo. Except to prevent freezing, and perhaps sweating, it has no advantage over the single, solid wall silo. W th both types of silo, any kind of door, roof, chute, etc., desired may be constructed with equal ease.

3. The cement block or concrete block silo is built of arch shaped hollow blocks, laid in cement mortar, and reinforced with steel hoops, which fit in between every second or third course according to the size and depth of silo and size of hoop. When finished, the silo is usually "painted" both inside and outside with a cement mortar to insure air-tightness. The block silo, like the hollow wall silo, has dead air spaces in the walls which tend to prevent freezing, although the block wall is not usually quite as effective in this respect as the hollow wall, since the air-space is rarely continuous. The principal advantage of the concrete block silo lies in the ease with which it can be constructed. It requires less labor than either of the other types, after the blocks have been made. However, where the blocks must be bought of some block manufacturing company, their cost often makes this type of silo the most expensive, and this fact must be given due consideration.

CONCRETE BLOCK SILO.

The size of the silo depends upon the number of cattle to be fed and the number of days their feeding continues. It does not pay to build a silo for less than ten head of cattle. The diameter, inside measurement, should never be more than one-half the height, and in practice it is not found advisable to make it over 20 feet.

NUMBER OF COWS.—The number of animals to be fed should determine the diameter of the silo, and the length of time silage is wanted should determine the height of the silo. The amount to be fed per cow must be determined first. Decide whether each cow is to have 20, 30, 40, or 60 pounds per day. Forty is the usual amount. Then having decided this point, make the diameter of the silo such that by feeding the cows so much per day the silage can be fed down at least 2 inches per day, as this will prevent molding of silage. If a silo is made too large in diameter,—and this is the most frequent error,—one of two things will happen. First, the silage will be moldy all the time, owing to the inability to feed it down rapidly enough, or, second, the cows will be fed more than they should have in an attempt to keep ahead of the molding.

Where a large number of cows are kept and it is expected to feed 40 or 60 pounds per cow, daily, it frequently happens that it is desirable to cut down the silage ration. It is well to have the diameter of the silo small enough so that the ration can be reduced one-third or even one-half and still be able to feed down the silage 1 to 1½ inches daily.

In the dairy section, many farmers consider this point so important that they are building two small silos instead of one large one, so that they can feed a light ration and still feed down the silage rapidly enough to prevent molding. In the older dairy sections, where silos have been longest in use and dairymen have used up their first silo and are building the second time, they build two small ones in place of the one large one. They also build smaller in diameter and higher.

About fifty cows seem to be the most that can be fed with advantage from one silo.

In selecting a proper location for a silo the following conditions must be met: (1.) The silo must be convenient for feeding. (2.) The silo must be located on solid ground. (3.) No odors from the silage should enter the barn.

1. The silo should be as near as possible to the feeding stalls, preferably at the end of the feedway. Silage is a heavy feed, and as some must be handled each day, by locating the silo in this way, much labor is saved.

2. The weight of the silo and its contents are very great. The foundation must, therefore, be placed on solid ground, so there will be no settlement.

3. Milk readily absorbs odors, and if the odor from the silage is allowed in the barn during milking-time, it can be noticed in the taste of the milk. This taste disappears, however, when the milk is made into butter or cheese, and in no way affects the keeping qualities of the milk.

SECURE FOUNDATIONS.—Since the silo and its contents are very heavy, it must be built on solid ground and the bottom of the foundation must go below the frost line. A depth of 5 feet below the ground level will be sufficient. This depth will prevent any possibility of the silo being blown down, and usually furnishes hard ground for the foundations to rest on. If good ground cannot be found upon which to build the silo, the foundation should be strengthened by using the same kind of steel or wire recommended for the walls. This reinforcement should be placed after the first 3 or 4 inches of concrete has been deposited and while the concrete is fresh. A footing properly reinforced in this way will settle evenly in soft ground without cracking the walls of the silo.

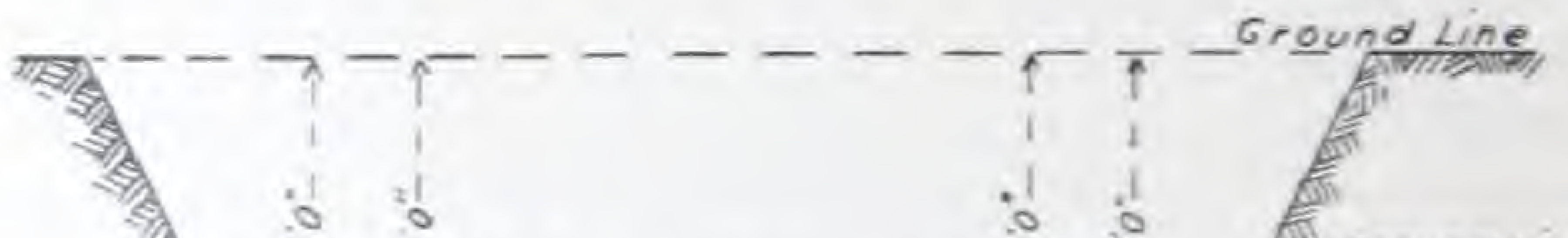


Fig. 102. Section through excavation for Silo.

Fig. 102 is a drawing of how the hole in the ground would look if it could be cut exactly in half and could be seen from one side. This hole is dug larger at the top than at the bottom, to prevent the sides from caving in while the concrete is being placed. After a proper excavation is made, fill in the trench to the proper depth and the center of the excavation to a depth of 4 inches with a 1:3:6 mixture of concrete of medium wetness. This will make the top of the concrete in the trench and in the center the same level. The concrete should be throroughly tamped, and the center smoothed off. During the concreting, place the reinforcement as described later.

CAUTIONS.—Be sure the earth under the footings is very dry and firm. Do not remove the last 2 or 3 inches in the trench until just before the concrete is mixed. If rain interferes, always remove the softened soil and pump or bail out all water before placing the concrete.

If the ground is so soft that the trench cannot be dug with straight sides, a few stakes and boards can be placed around the edges of the trench to hold up the sides while the concrete is being placed. Be sure the trench is as wide as the width shown

SILO WALLS—FORMS AND CONSTRUCTION.

With the foundation and floor in place, the circular walls of the silo can be started at once. There are five operations in the constructing of the walls:

1. The forms must be built and set, ready for the concrete.
2. The reinforcement placed.
3. The concrete mixed, and deposited in the forms around the reinforcement.
4. The forms removed, hoisted, and reset, ready for the next section of concrete.
5. Openings formed in walls for doors, placing of anchorbolts for roof and chute, and other details.

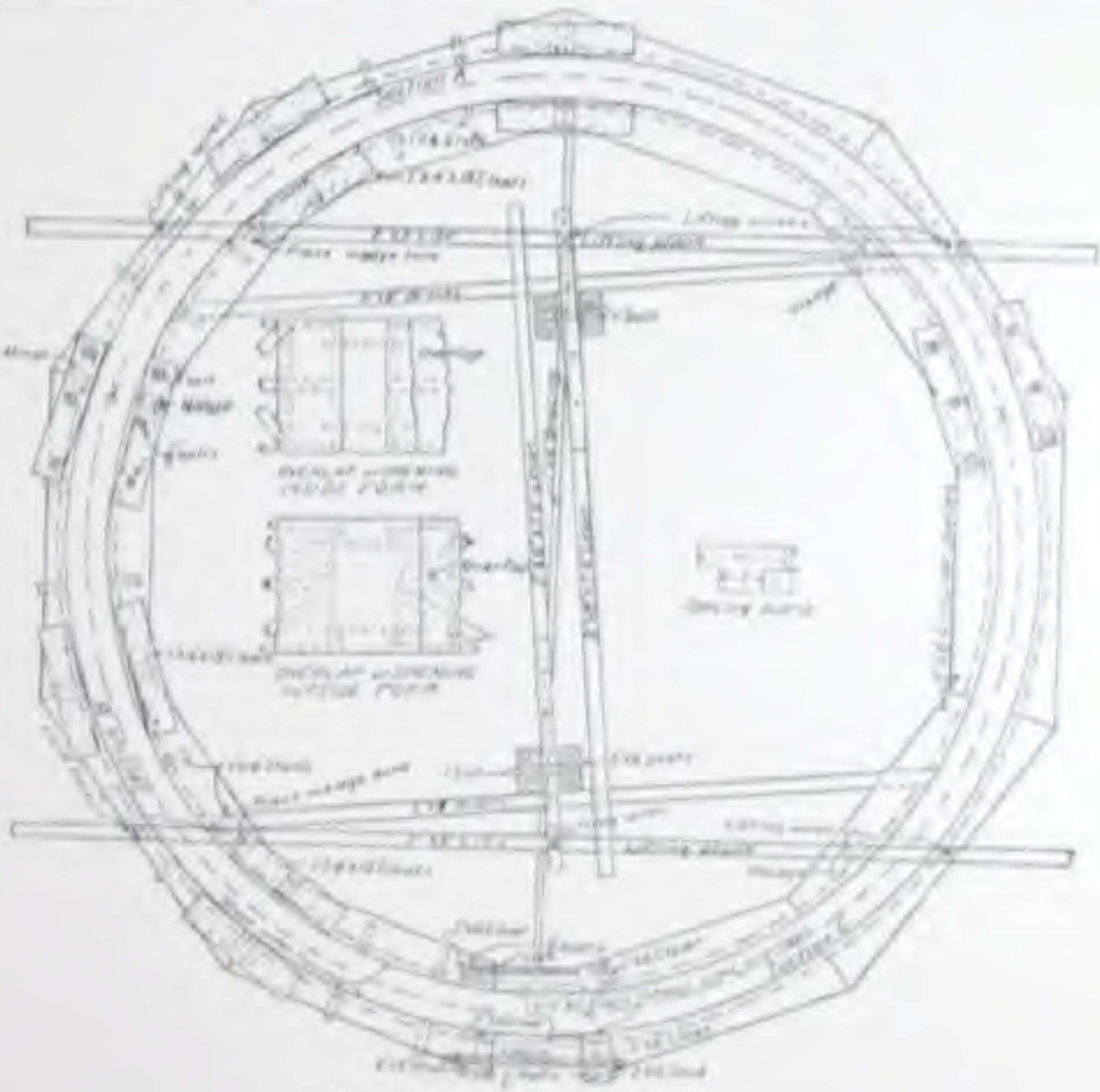


Fig. 103. Details of Silo Forms.

The several operations will be explained in the order given, except item No. 2 which will be taken up separately under "Reinforcement," and item No. 5 which will be explained under the various headings.

1. WALL FORMS.—The wall forms are circular in shape, one inside of the other, the concrete being placed between them and thus forming the required wall. These forms are kept 6 inches apart so that the silo walls will be 6 inches thick when completed. The forms are 3 feet high, so that the lower 3 feet of the silo can be built at one time, without shifting forms. After the first 3 feet of concrete is in place, the forms are loosened by means of the adjusting bolts shown in Fig. 103 (also details in Fig. 104), raised by the levers and again set in place by the adjusting bolts. This operation is repeated until the silo walls are built.

The principal parts of both the inside and outside forms consist of pieces of 2x6 inch planks, cut circular.

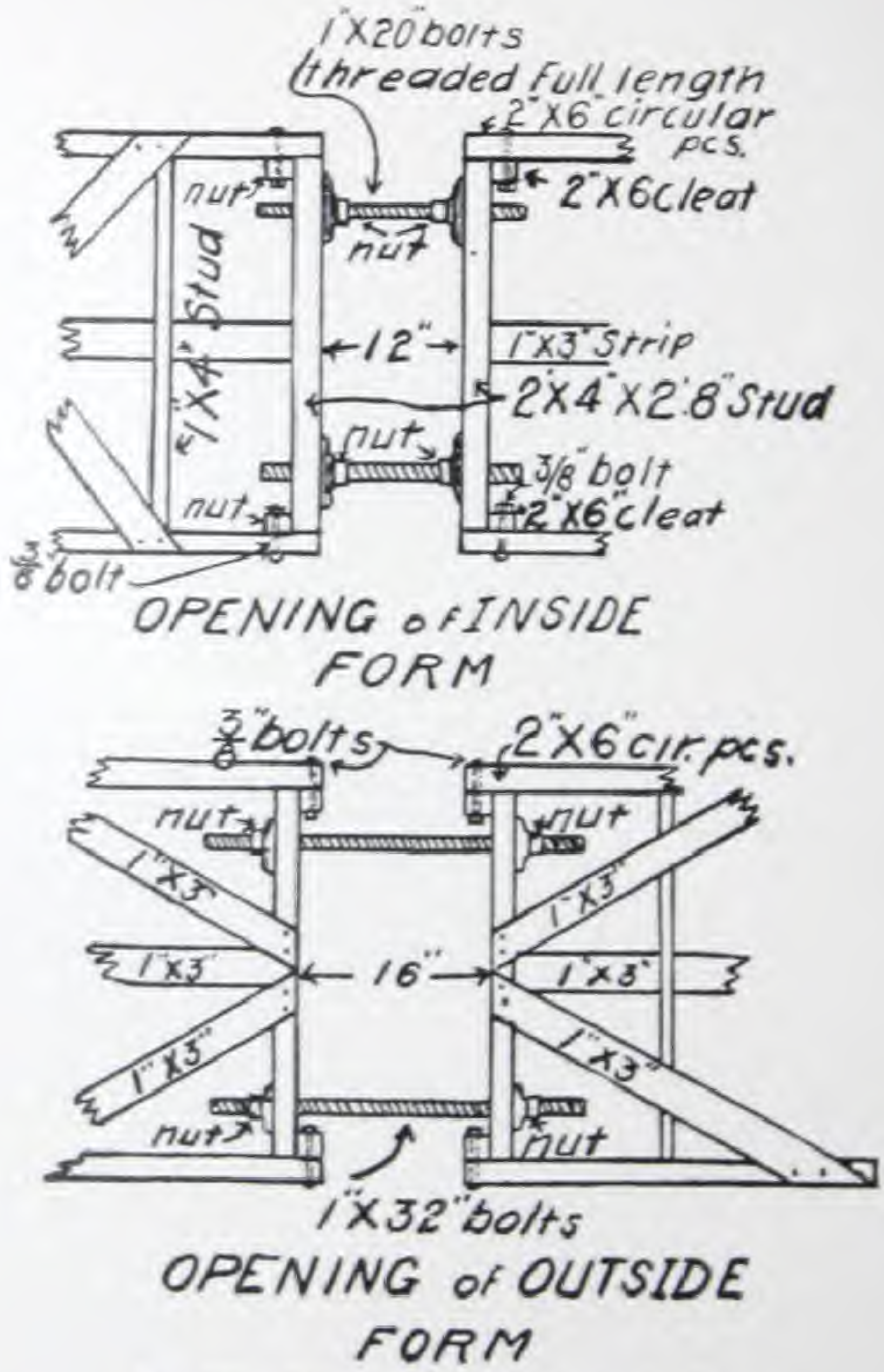


Fig. 104. Details of tightening device for Forms.

Fig. 105 illustrates an easy method of marking the 2x6 inch pieces so as to saw them correctly. Take any level place in the house or barn and drive a wire nail in the floor. With a string attached to the nail, mark off a small part of a circle with a piece of chalk attached to the other and of the string making the length of string 5 feet for a 10-foot silo. This mark gives the curve of the inside face of the form. Lay a piece of 2x6 inches by 3 feet, 2 inches on the curve described above and as shown in the upper half of Fig. 105.

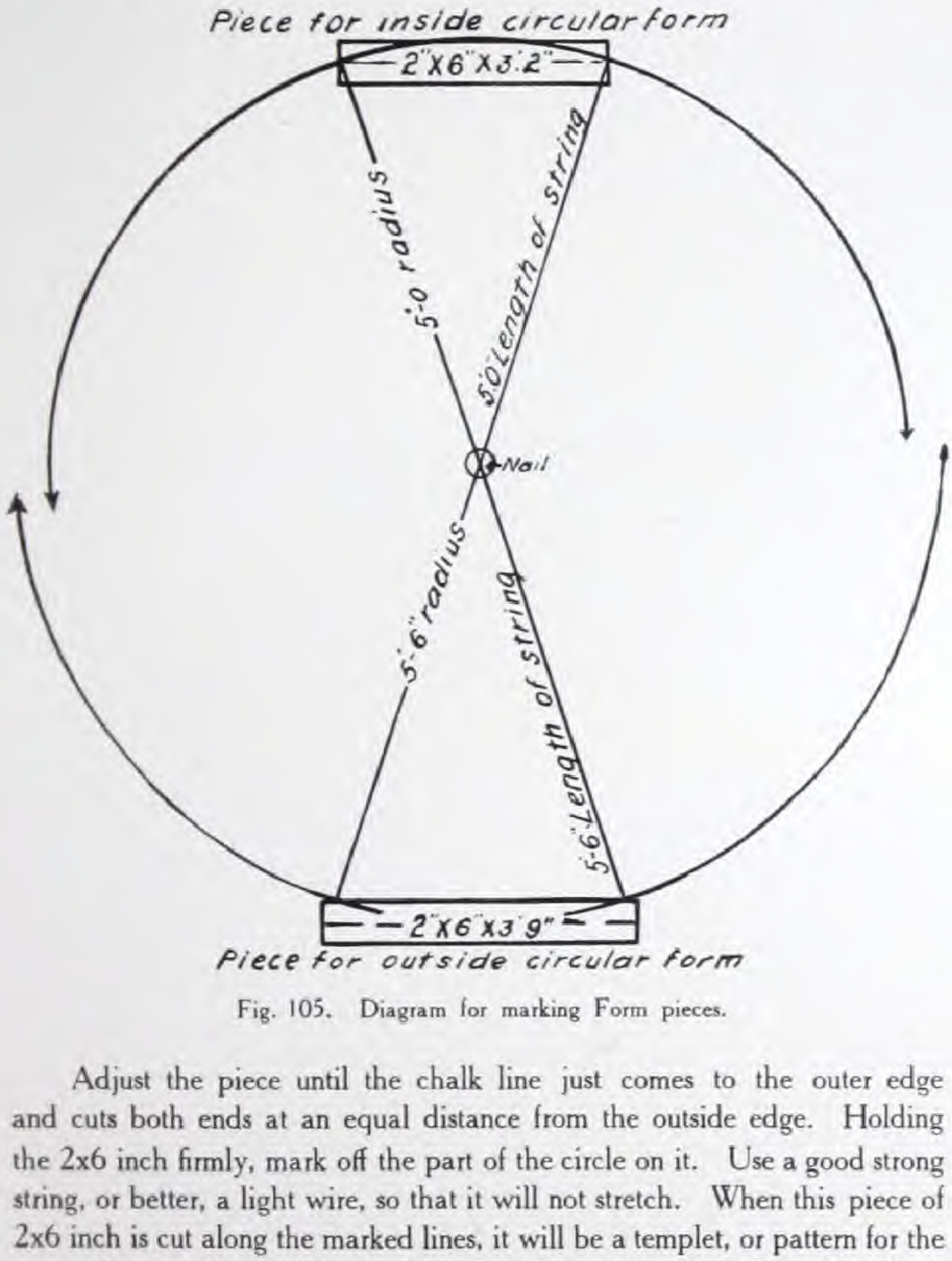


Fig. 105. Diagram for marking Form pieces.

Adjust the piece until the chalk line just comes to the outer edge and cuts both ends at an equal distance from the outside edge. Holding the 2x6 inch firmly, mark off the part of the circle on it. Use a good strong string, or better, a light wire, so that it will not stretch. When this piece of 2x6 inch is cut along the marked lines, it will be a templet, or pattern for the rest. After cutting five or six pieces lay them out on a circle and see how they fit the curve, making any slight corrections necessary.

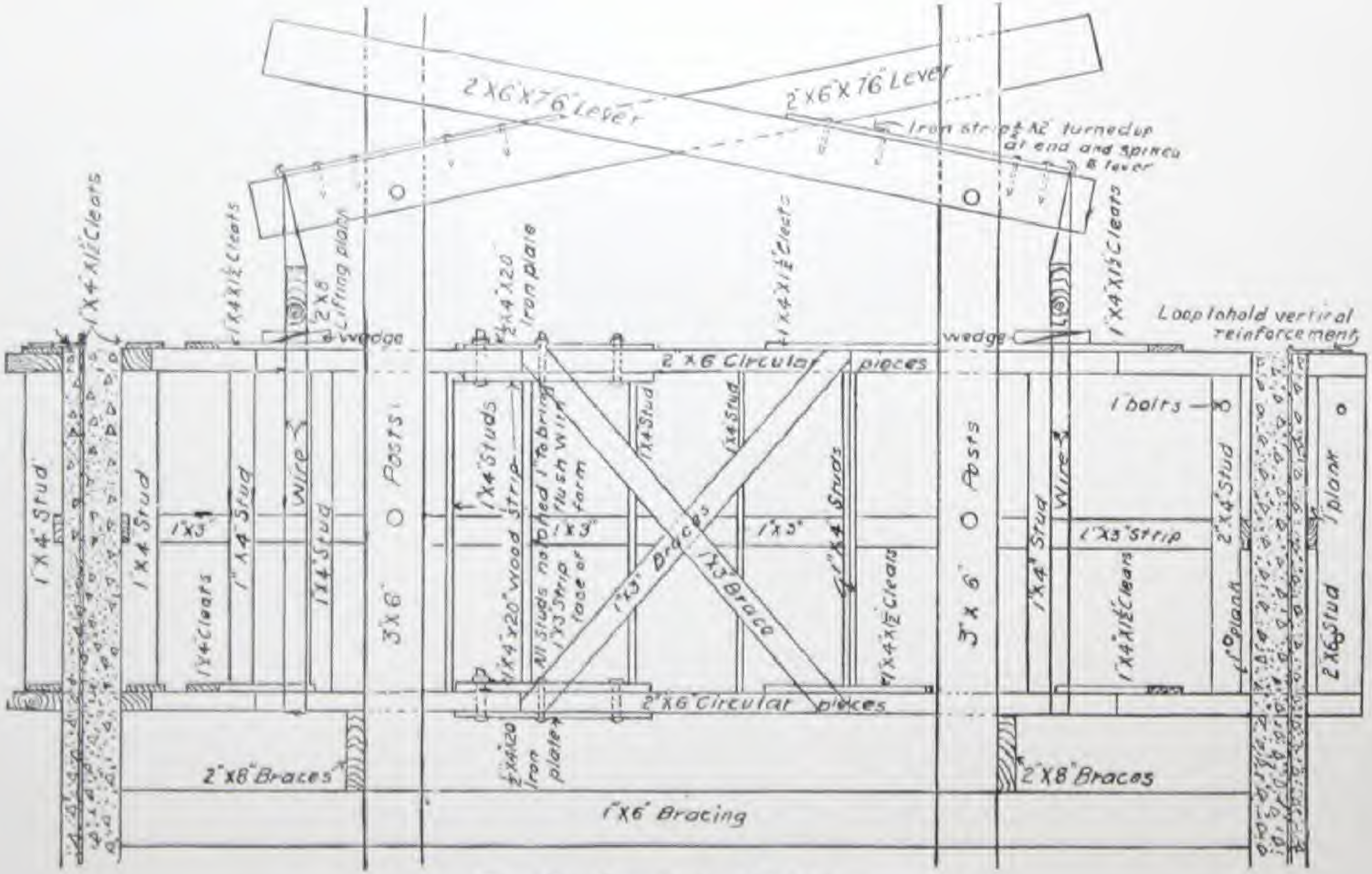


Fig. 106. Cross-Section of Silo Forms.

The templet piece for the outside form is made in exactly the same way, except that the length of the string is increased the width of the silo walls, a slightly longer piece of 2x6 inch is necessary, and the circular cut is taken out of the inside instead of the outside of the board.

These planks are held together by 1x4 inch cleats. There are four complete circles of these 2x6 inch pieces, one at the top and one at the bottom of each form. The circles are held apart by 1x4 inch studding placed with their edges flush with the circular side of the 2x6 inch pieces, two studs to each piece of 2x6 inch plank. This framework is further braced by 1x3 inch diagonal braces—a pair of diagonal braces being used for each section of the circle. A 1x3 inch strip is sprung around the middle of the frame, the 1x4 inch studs being sawed out 1 inch to receive it on

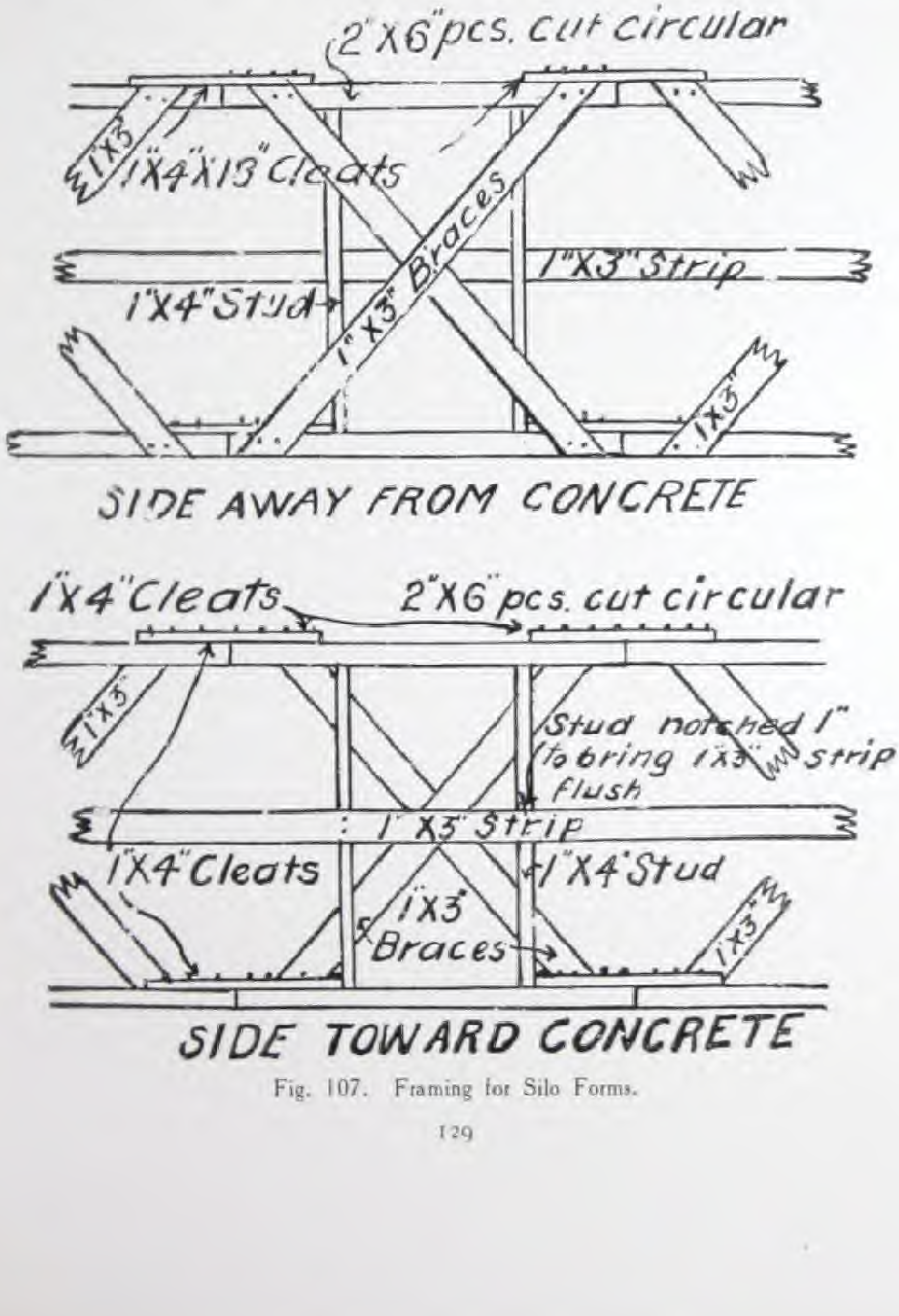


Fig. 107. Framing for Silo Forms.

the edge toward the concrete. This makes the circular 2x6 inch pieces, the 1x4 inch studs, and the 1x3 inch strip all flush on the face of the form toward the concrete. On this circular surface is nailed the sheet steel (No. 24 gauge) which is the real form that holds the concrete.

Both inside and outside forms have screw-bolt devices for separating and pulling them together. Each has two sets of hinges to allow the forms to be separated or pulled together. These hinges, with the space for operating the adjusting bolts, divide the forms into three sections, lettered A, B and C, in Fig. 103.

Fig. 103 is a view of the silo forms and scaffolding as they would appear to a person above the silo looking down.

Fig. 106 is a section of the silo under construction taken straight across the silo. It shows how the forms and scaffolding would look if the silo could be cut in two down the middle.

These two figures show exactly how the forms are constructed and operated.

While the 2x6 inch circles are lying on the smooth floor, the holes for the hinges should be bored. These hinges consist of two ½ inch iron plates, placed on both sides of the 2x6 inch pieces. They are fastened to the ends of section B and C with two 1 inch bolts, and to the ends of section A with one 1 inch bolt. This bolt is not placed until the forms are in position, and is not drawn tight. This allows for the hinge action.

Fig. 107 illustrates one section of the frame work of the forms, showing how the 1x4 inch studs, the 1x3 inch cross-braces, and the 1x3 inch strip are placed for each pair of 2x6 inch circular cut pieces which form the top and bottom of the framework.

SHEET STEEL.—Nail on the No. 24 gauge sheet steel. Sheets come in different sizes, and it is suggested that whatever can be obtained from stock at the dealers be used. Always have a stud at the vertical seam of the sheet steel, and if a horizontal seam is necessary, move the 1x3 inch strip up or down so as to be opposite the seam. Also at both the hinges, let one side overlap the other about 2 inches. Take care, however, that this extra lapping piece does not interfere with the free operation of the hinges. If the hinges are arranged as shown in Fig. 103, the overlapping pieces at each hinge should be attached to section A. There should also be 14 inches of overlap at the opening in both the inside and outside forms, so that the full width of the top piece is next to the concrete. If there is any overlapping along horizontal seams, the top piece of sheet metal should always overlap the bottom piece.

The face of the sheet metal form should be painted with a thin coat of black or cylinder oil, and repainted whenever necessary to keep the concrete from sticking to it.

WOODEN FORMS.—The face of the silo wall forms may be made of 1 inch tongued and grooved boards in place of the sheet metal shown in Figs. 103 and 106.

The forms are now ready to be carried to the silo site and placed in the correct position on the footing for the first course of concrete. Set up the inside form first, and level it very carefully, putting in the hinge bolts in the ends of section A, and the adjustment bolts between sections B and C as described in the next paragraph.

Make about a dozen spacing boards, place the outside form, put the boards between the forms and then draw the inner and outer circle tight by means of the adjusting bolts, adjusting the lower bolts the same amount as the upper ones. The spacing boards should be placed around the circle about every 3 feet for the first trial.

In placing the forms remember to place the openings in the forms directly toward the side or point at which the hoisting of concrete is to be done, when the silo wall gets above the ground. The openings have nothing whatever to do with the hoisting of the concrete, but right back of these openings will be two 3x6 inch posts, by means of which the hoisting is to be done.

THICKNESS OF WALLS.—The thickness of the silo wall can easily be increased over the 6 inches shown, by setting the outside form further away from the inside form and increasing its length slightly.

PLACING CONCRETE FOR FIRST TWO COURSES.—Everything is now ready for the placing of the concrete, with the exception of placing the reinforcement (explained later). As the second 3 foot course of concrete only brings the top of the form two feet above the ground-line, both these courses, and also the third, should be placed by shoveling directly into the forms from the concrete board or if the mixing is being done at a distance from the site of the silo, by dumping the wheelbarrow loads directly into the forms. Mix the concrete wet, so that it will need little tamping. Place it in from 4 to 6 inch layers and spade it thoroughly next to the forms. An iron spade is too clumsy for a 6 inch wall and is apt to catch on the nails holding the sheet metal. Use a tool made of wood instead.

Make each 6 inch layer of concrete level before starting a new layer. Before placing any concrete on top of any which has set, the concrete already in place should be carefully cleaned off by sweeping and then flushing with water. Also scatter a few handfuls of dry Portland cement over the old concrete and rub it well into the old concrete with a scrub brush. This should be done each time before starting to fill the forms after raising.

Fill the form flush with the top and carefully even off the edges. Rough up the center of the top of the concrete as much as possible. This gives a good bond for the next course.

After the forms are filled with concrete, place the scaffolding, and arrange some such form-lifting device, as shown in Figs. 103 and 106.

CAUTION.—As the work goes up, be sure to brace the 3x6 inch posts securely. They will carry the weight of the forms easily enough, but not without proper bracing. Do not raise the forms above the finished wall, as trouble will be experienced in getting them back in place. Be careful to raise the forms slowly and to work both levers (if used) at the same time in raising, so that the forms will be raised without binding.

Mix only two-bag batches at a time, and place the whole batch before starting a new one.

BACK-FILL.—After the first three or four courses are placed, dirt should be filled in the hole next the concrete wall, and carefully tamped, leaving the ground next to the silo wall a little higher than the surrounding ground.

HANDLING THE CONCRETE FOR SILOS.

After the 3 foot form has been used three times, and is set in place for the fourth time, the top of the form will be 8 feet above the ground outside the silo, and too high to shovel into. Therefore, some method of hoisting the concrete must be used. The easiest way is to hoist the concrete in galvanized iron buckets or coal-scuttles. For the fourth course, the buckets can be handed up, but above that point they must be hoisted by a rope. For quick work it is best to rig up a block and fall and use a horse to do the hoisting, raising 3 or 4 buckets at one time.

CAUTION.—In hoisting by horse or engine, as is sometimes done, the 3x6 inch posts must be well braced and guyed so that they will not be pulled out of plumb.

The concrete in silo construction should be carefully mixed wet and the forms made tight to prevent the loss of any cement grout.

The concrete in the footings and floor should be proportioned 1:3:6.

The concrete in the silo walls should be proportioned 1:2:4.

If, on raising the forms, open spaces between the stones are found, due to carelessness in spading or on account of a leak in the form, these places should be patched at once. First remove all the loose pebbles and rough up the surface to get a good bond. Then fill the hole with a 1:2 Portland cement mortar, making the outside flush with the rest of the surface. If patched at once and then painted later with cement grout, the place will not be noticeable. Be careful not to let the patched place dry out more rapidly than the surrounding concrete. This can be prevented by wetting every day with water applied by means of a whitewash brush.

As before explained, the inside of a silo should be as smooth as possible, to permit the silage to settle evenly.

As the wall is built, slight rough spots are sometimes left, due to concrete sticking to the forms. These can be easily made smooth by applying a coat of cement mortar, consisting of one part Portland cement and one part fine sand, mixed with water to the consistency of cream. Apply this with a whitewash brush. Before applying, brush the wall thoroughly with a dry stiff brush. Then wet the wall until the water is not instantly absorbed by the concrete, and then apply the wash, while the wall is still wet. Stir your cement and sand mixture constantly while applying. If this is not done, the cement and sand settle to the bottom, and you will be painting your wall with water only. Mix this grout in very small quantities and put on a thin and not a thick coat over both the inside and outside of the silo.

This treatment not only makes a smooth wall, but also tends to make it waterproof. There are a number of patented water-proofing compounds, which can be mixed with the cement grout, or with the concrete, but if the concrete is properly proportioned and placed, it will be waterproof in itself. By using the form posts for scaffolding, before taking down, the inside of the silo can be easily painted. The outside can be painted from a swinging scaffold, hung from the top.

In the description of the erection of the silo walls, no mention was made of the silo doors, openings for which must be left in the concrete walls. Fig. 108 is a vertical section through the silo, showing one arrangement of the silo doors. The doors are 2 feet by 2 feet and are spaced 3 feet apart starting at 1 foot above the ground-line. The number of doors can, of course, be increased or diminished at the will of the builder. These doors should be placed on the side of the silo nearest the feeding troughs.

The lumber used for the doors should be the most durable wood obtainable and should be surfaced on all sides.

Silos are sometimes made with continuous door openings, where tongued and grooved planks are used for doors, depending upon the pressure of the silage to keep them in place. Special metal ties must then be put across the opening to take the place of those omitted where no concrete is placed. This is important.

A special form is to be used to make the openings in the walls for the doors. It consists of a box open on the front and back, having straight sides and a circular top and bottom so that it will just fit between the silo forms. All the sides are beveled. The box is ready for use as soon as it is cross-braced on the inside, so that it will keep its shape. To place the door opening form inside the silo forms, bring the concrete up to about 1 inch higher than the level for the bottom of the opening. Have the concrete very soft with an inch or so of mortar on top where the opening is to

come. Shove the box form down into the concrete until it is at the right height and concrete around it, carefully spading the concrete along the sides of the box. A good plan is to mix up a little 1:2 mortar and keep putting it next to the box form as the concrete is placed. 1:2 mortar should always be placed about ½ to ¾ inch thick over the top of the box form. On account of the spacing of the doors, the opening will not always come all in one 3 foot height of silo forms. In this case leave the box form in place and raise the silo forms as if it were not there. Care should be taken in this case to clean away the old mortar from the sides of the box above the form in order to make a good bond at this point.

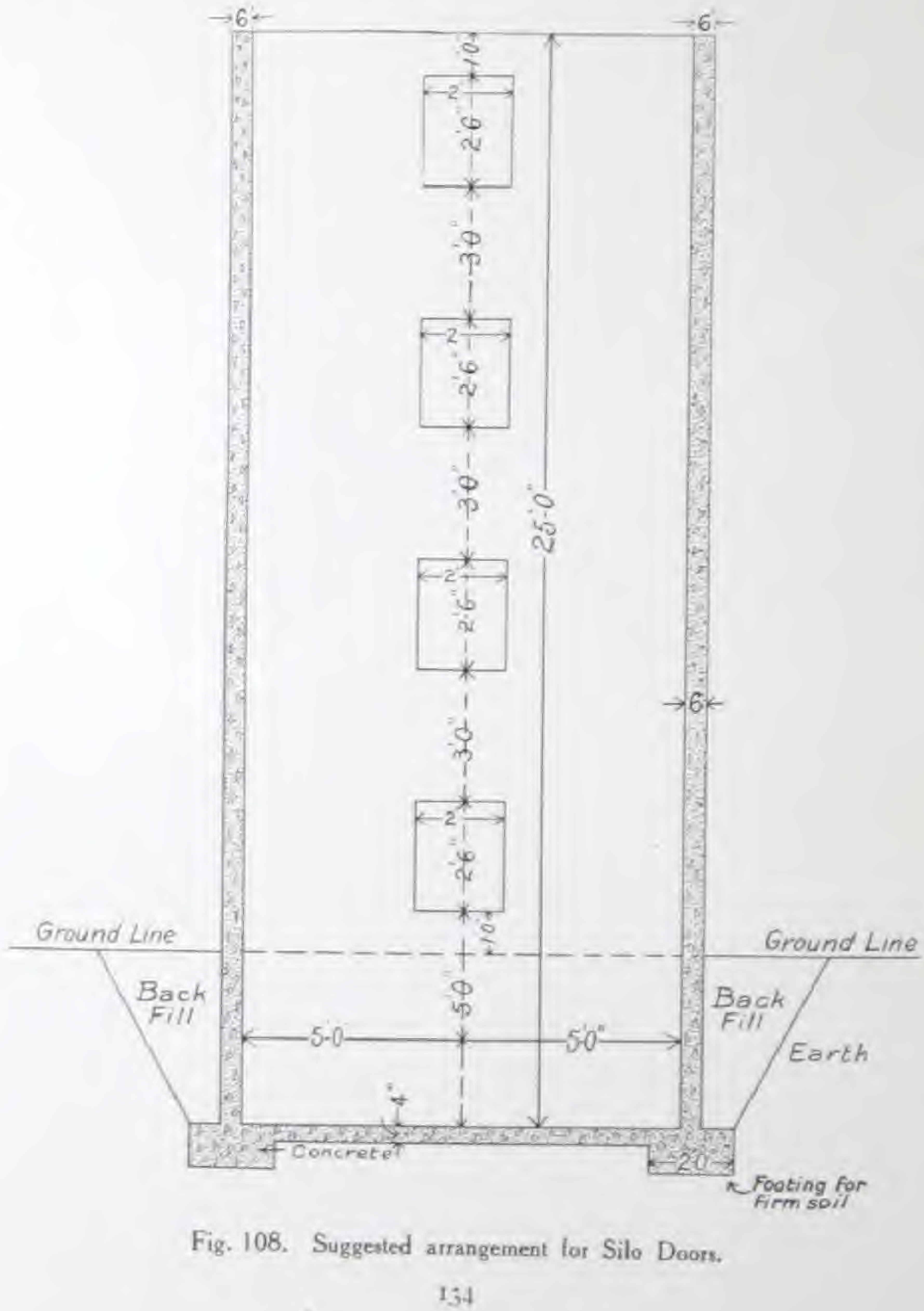


Fig. 108. Suggested arrangement for Silo Doors.

There must be two of these box forms made, and each should be left in place until absolutely needed again, as this allows the concrete over the opening to harden before the box is removed. Before using, these boxes should be carefully painted with a couple of thin coats of black or cylinder oil. They should be wiped off before using, and when not in use should be kept out of the sun, to prevent warping.

The ladder up the side of the silo along the doors can be made in many ways. One way is to bend round bars into the shape shown in Fig. 109 and place them in holes in the concrete, afterward filling any space around the bars with cement mortar. These holes can be formed by the use of wooden plugs molded in the work during the placing of the concrete, and removed as soon as the forms are raised.

The last mentioned diagram gives the best spacing for the ladder, and plugs can be placed properly by measuring from the openings. Be careful not to get the holes nearer than 4 inches to the openings.

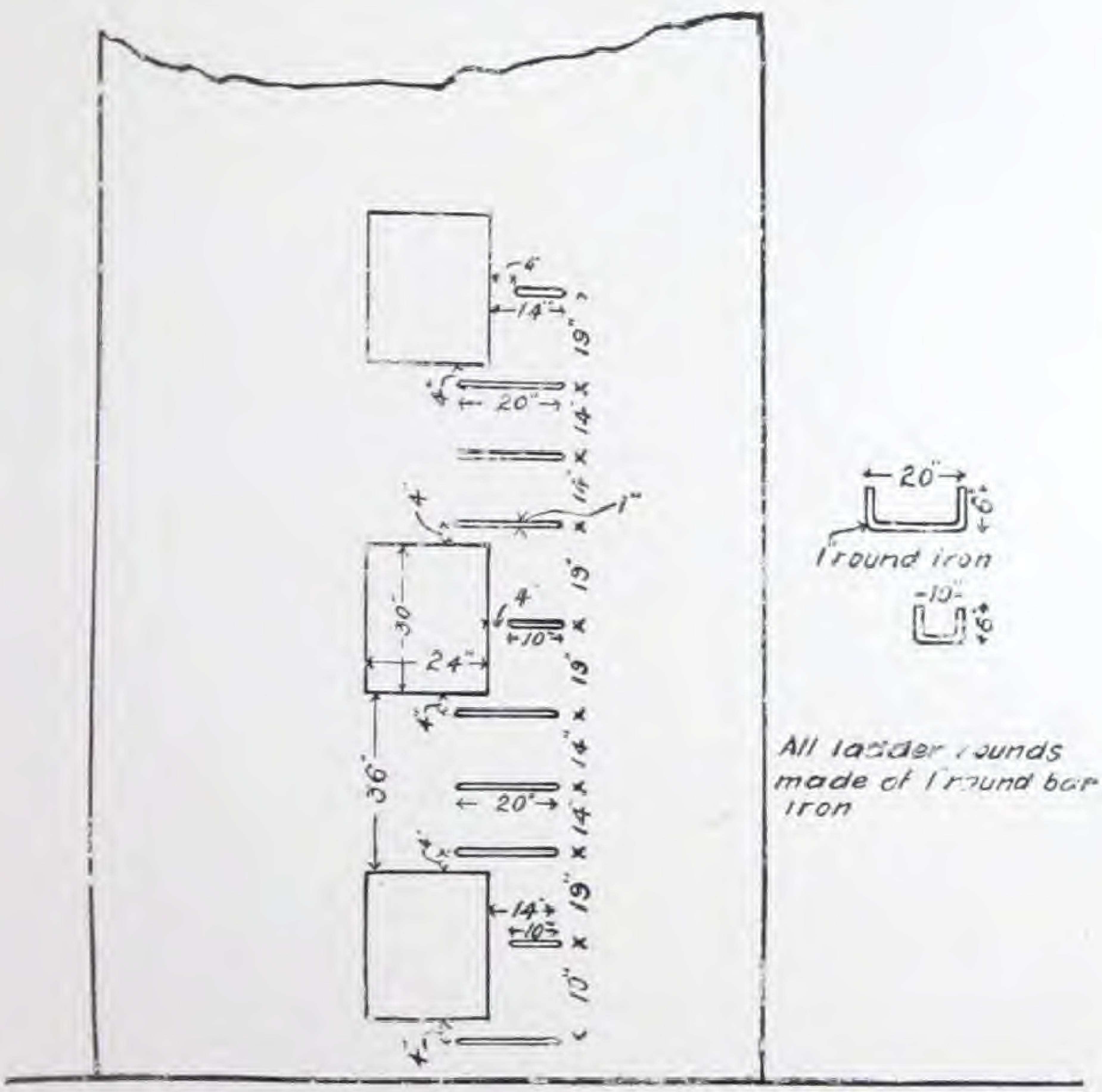


Fig. 109. Suggested Ladder Details.

In many localities it is found most convenient to have a chute surrounding the silo doors. Fig. 110 shows a horizontal section of a simple design for making a wooden chute.

Chutes are sometimes made of concrete. Where a roof is placed over the chute, it is well to have one or two windows in it.

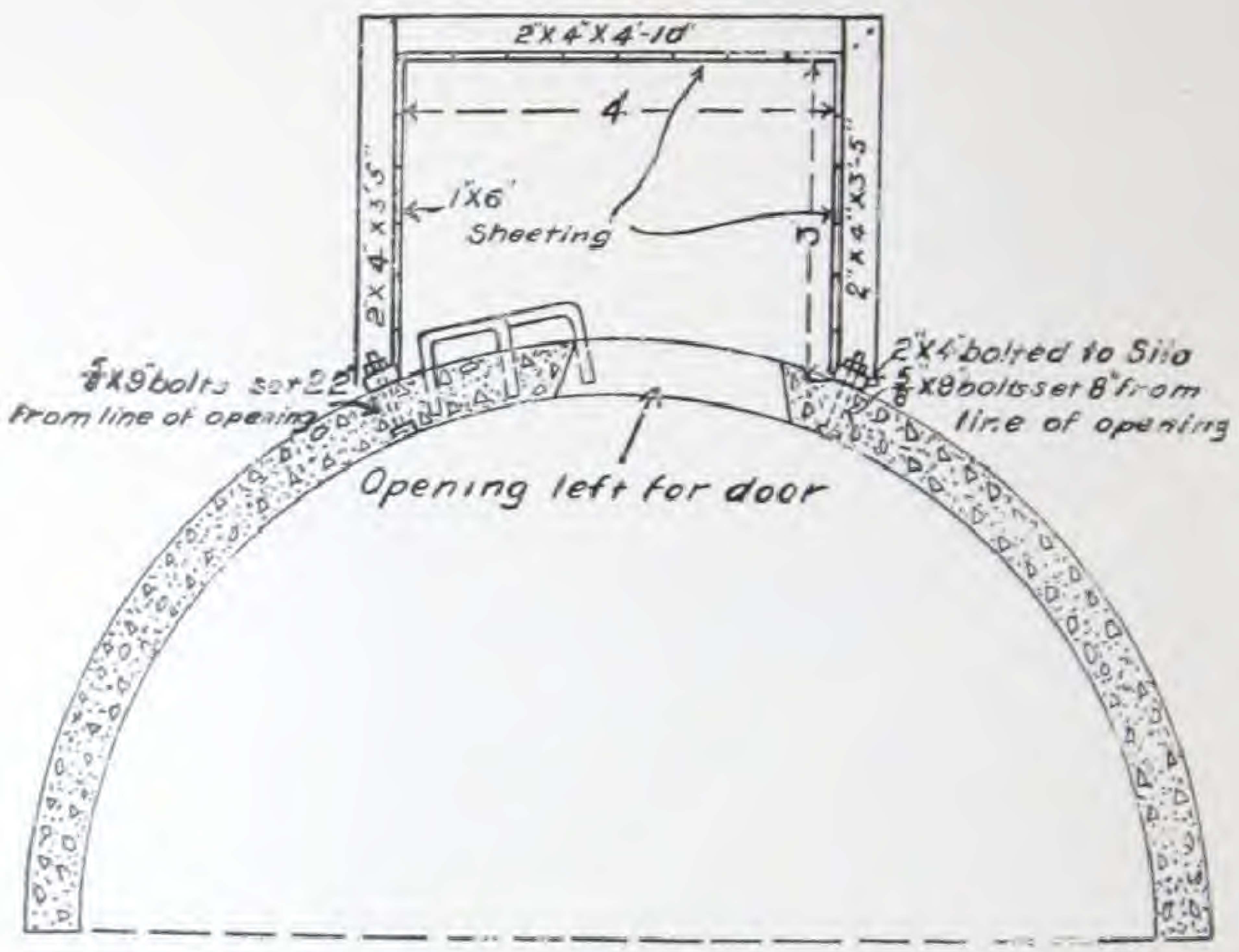


Fig. 110. Arrangement for a Wooden Chute.

REINFORCEMENT FOR SILOS.

The reinforcing of the silo walls with small steel bars or steel wire must be done with accuracy and care, as the strength of the silo depends on the correct use of steel in the walls. The silo walls are reinforced in two directions—vertically, to prevent failure due to wind pressure, and horizontal, to prevent failure due to the pressure of the silage. Silage is a heavy material, and is estimated by the various State experimental stations to exert a side pressure of 11 lbs. per square foot for every foot in depth.

It is on the basis of this estimate that all the calculations in Tables V and VI are based. The vertical reinforcement consists of tie rods running from the top of the wall down into the footing. The horizontal reinforcements are hoops. There are many kinds of patented reinforcing bars, but these offer no great advantage over plain round bars or wire for silo reinforcement.

Tables V and VI show the spacing for the reinforcement when using several different sizes of steel wire, and also for 3/8 inch steel bars, for any size of silo.

TABLE V.

Height of Silo in Feet	Size and Spacing of Vertical Reinforcement.									
	For Silos 10' to 13' Inside Diameter					For Silos 14' to 17' Inside Diameter				
	Spacing in In. for 3/8" Mild Steel Bars & No. of Bars Used	Spacing in In. and No. of Strands Used for Diff. Gauges of Steel Wire				Spacing in In. for 3/8" Mild Steel Bars & No. of Bars Used	Spacing in In. and No. of Strands Used for Diff. Gauges of Steel Wire			
		Gauge No. 000	Gauge No. 2	Gauge No. 5	Gauge No. 8		Gauge No. 000	Gauge No. 2	Gauge No. 5	Gauge No. 8
25' and under	1–30"	1–36"	1–19"	3–36"	3–22"					
25' to 30'	1–19"	1–24"	2–25"	3–23"	6–28"	1–25"	1–30"	2–33"	3–31"	6–36"
30' to 35'	2–26"	1–16"	3–26"	6–32"	9–29"	1–18"	1–24"	2–24"	3–22"	6–28"
35' to 40'	2–19"	2–24"	3–18"	6–23"	12–28"	2–27"	1–16"	3–26"	6–32"	9–30"

TABLE V Continued

For Silos 18' to 20' Inside Diameter.

Height of Silo in Feet	Spacing in In. for 3/8" Mild Steel Bars & No. of Bars Used	Spacing in Inches and Number of Strands Used for Different Gauges of Steel Wire			
		Gauge No. 000	Gauge No. 2	Gauge No. 5	Gauge No. 8
35' to 40'	1–17"	1–21"	2–22"	3–21"	6–26"

NOTE:—American Steel and Wire Co.'s gauges used. 3/8" bars are round, 3/8" in diameter.

No figures are given for silos 18' to 20' in diameter less than 35 feet high, or silos 14' to 17' in diameter less than 25 feet high, as these are not good proportions for silos.

Several choices are given, so that the reinforcement may be bought from stock.

TABLE VI.

Distance in Feet Measured from Top of Silo.	Sizes and Spacing of Horizontal Reinforcement around Silo. For Silos 10' to 13' Inside Diameter.				
	Spacing in In. for ⅜" Mild Steel Bars & No. of Bars Used	Spacing in Inches and Number of Strands Used for Different Gauges of Steel Wire.			
		Gauge No. 000	Gauge No. 2	Gauge No. 5	Gauge No. 8
0' to 5'	1–18"	1–18"	1–18"	1–16"	1–12"
5' to 10'	1–18"	1–18"	1–16"	1–11"	1– 7"
10' to 15'	1–15"	1–18"	1–12"	1– 7½"	2– 9"
15' to 20'	1–14"	1–17"	1– 9"	1– 6"	3–10"
20' to 25'	1–11"	1–14"	1– 7"	2– 9"	3– 8"
25' to 30'	1– 9"	1–11"	1– 6"	2– 7½"	3– 7"
30' to 35'	1– 8"	1–10"	1– 5"	2– 6½"	3– 6"
35' to 40'	1– 7"	1– 8"	1– 4½"	2– 5½"	3– 5"

TABLE VI—Part 2

For Silos 14' to 17' Inside Diameter.

0' to 5'	1–18"	1–18"	1–18"	1–12"	1–11"
5' to 10'	1–18"	1–18"	1–14"	1– 9"	1– 5"
10' to 15'	1–14"	1–16"	1– 9"	1– 6"	2– 7"
15' to 20'	1–11"	1–12"	1– 7"	2– 8½"	3– 8"
20' to 25'	1– 9"	1–10"	1– 5½"	2– 7"	3– 6"
25' to 30'	1– 7"	1– 8"	1– 4½"	2– 5½"	3– 5"
30' to 35'	1– 6"	1– 7"	1– 4"	3– 7½"	3– 4½"
35' to 40'	1– 5"	1– 6"	1– 3½"	3– 6½"	3– 4"

TABLE VI—Part 3

For Silos 18' to 20' Inside Diameter.

0' to 5'	1–18"	1–18"	1–18"	1–12"	1–9"
5' to 10'	1–18"	1–18"	1–12"	1– 7"	2–9"
10' to 15'	1–12"	1–15"	1– 8"	2– 9½"	3–9"
15' to 20'	1– 9"	1–11"	1– 6"	2– 7½"	3–6½"
20' to 25'	1– 7"	1– 9"	1– 4½"	3– 8½"	3–5½"
25' to 30'	1– 6"	1– 7"	1– 4"	3– 7½"	3–4½"
30' to 35'	1– 5"	1– 6"	1– 3½"	3– 6"	3–4"
35' to 40'	1– 4½"	1– 5"	1– 3"	3– 5½"	3–3½"

American Steel and Wire Co.'s gauges used; ⅜" bars are round, ⅜" in diameter.

Table VI shows the horizontal or "hoop" reinforcement around the silo and the vertical distance it is to be spaced in the silo walls. Since the pressure in a silo increases with the depth, it is necessary to make the walls much stronger at the bottom than at the top.

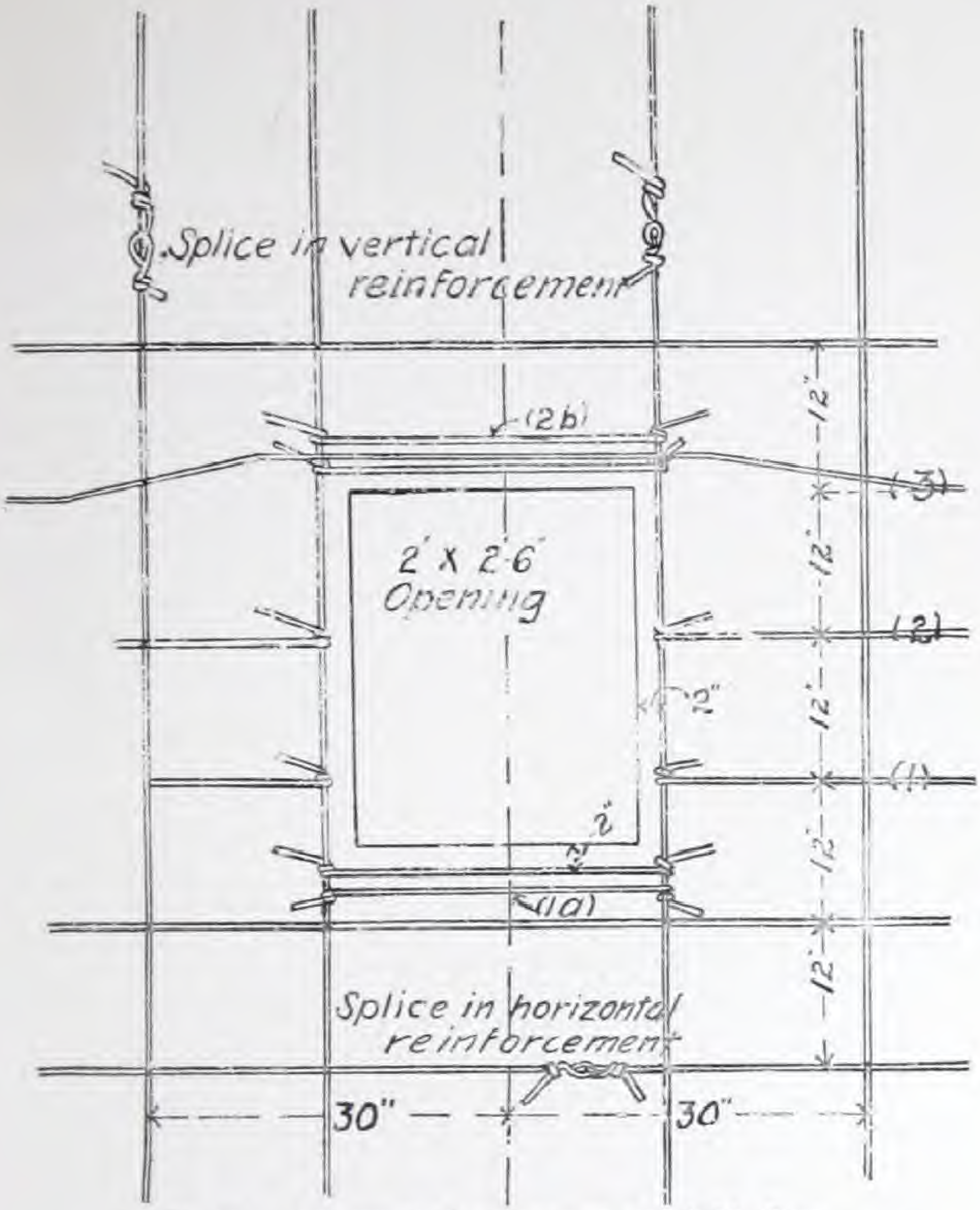


Fig. 111. Arrangement of reinforcement around Silo Door.

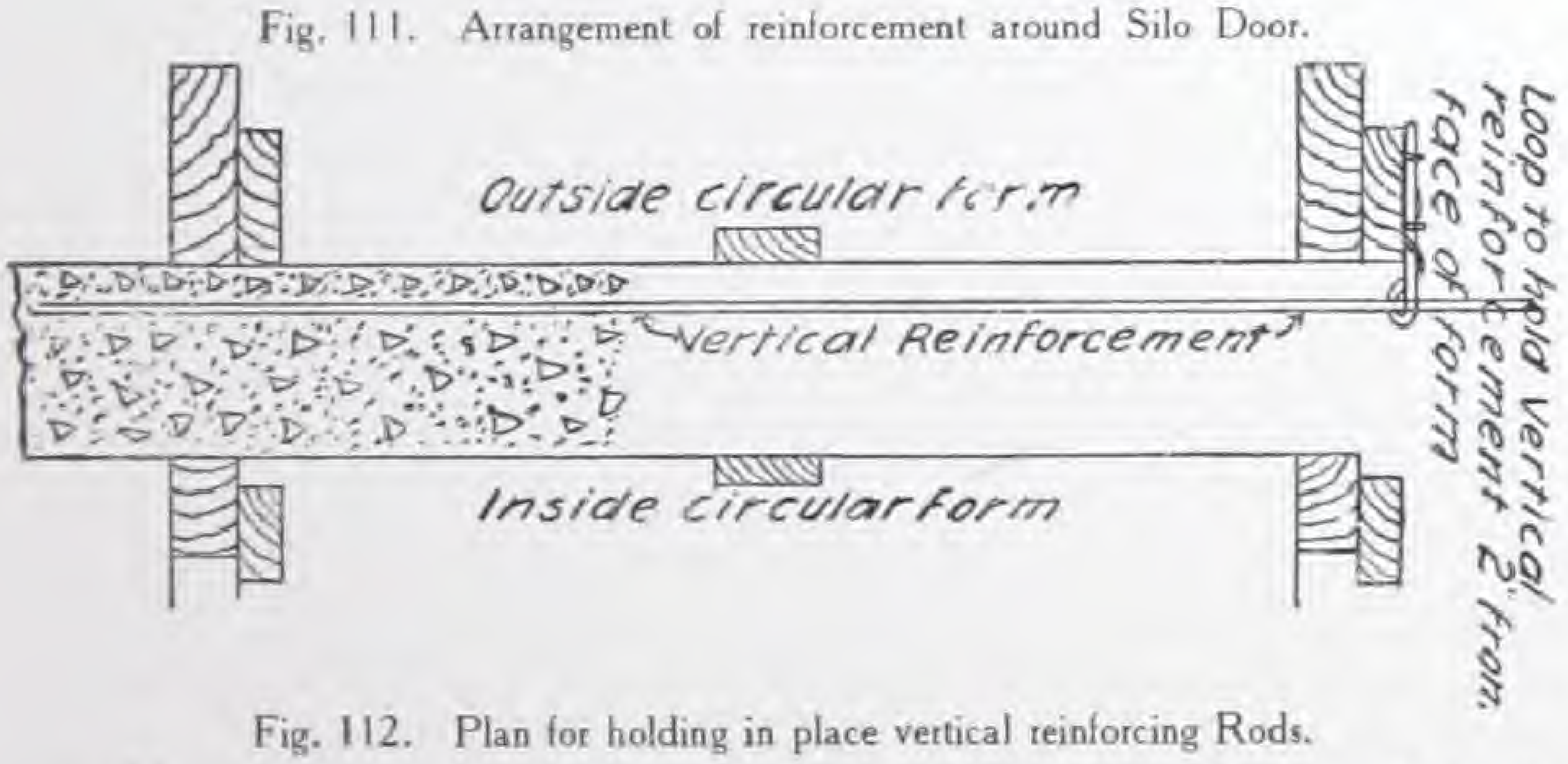


Fig. 112. Plan for holding in place vertical reinforcing Rods.

The same gauges of wire are figured in Tables V and VI, so that only one size of wire may be used for all the reinforcement, although it will

be slightly cheaper to order the heavier gauges for the lower sections of the silo and the vertical reinforcement and the lighter gauges for the top sections.

In no case should the horizontal wires or bars be placed over 18 inches apart or the vertical bars or wires placed over 36 inches apart.

The placing of the reinforcement is a very simple matter, but there are several points of importance to be noted.

1. To tie reinforcement to prevent slipping. The horizontal reinforcement should be cut in one length, if wire, and the ends looped together and twisted back. If bars are used, the ends should be bent around each other at each lap. The extreme ends of the vertical reinforcement should be tied by bending around four extra strands of the largest wire used, two wires being placed 2 inches below the top of the silo wall, and the others in the center of the silo footings.

The vertical rods should be placed in short lengths, as it is very hard to handle the forms with rods running the entire height of the silo. These short lengths can be twisted or spliced together, as the wall is built up. In starting the vertical reinforcement in the footing use only 2 feet 6 inches or 3 feet lengths, taking six inches to twist around the two horizontal tie rods or wires placed in the center of the footings. This will leave 1 foot 6 inches to 2 feet to stick above the finished footings. The next section of vertical reinforcement is tied to these short lengths, and they will not interfere with the setting of the concrete forms.

2. To place reinforcement around doors and openings.

Fig. 111 shows how the reinforcement is placed around the door openings. The short horizontal wires 2 inches above and below the opening are always placed regardless of where the horizontal reinforcement comes. Wire marked (3) comes near enough to the top of the opening to be bent up and over it without cutting and using an extra short piece. In order to hold the rods in place, bend a piece of wire as shown in Fig. 112, and hook it over the outside of the form.

3. The horizontal hoop reinforcement should be on the outside of the vertical reinforcement and about 2 inches from the face of the outside form.

A roof is essential to a good silo in order to keep the snow out and to prevent the silage from freezing. It helps the silage to hold its heat if proper attention is given to the closing of the silo doors during cold weather. Give enough pitch to the roof to shed snow. The roof is often pitched 45 degrees. This gives room for storing the silage several feet above the top of the wall and allows for its settlement after the final filling. It also gives enough room for a man to work during the filling. Build an ordinary trap-door between two of the 2x6 inch rafters on the side from which the silo is to be filled.

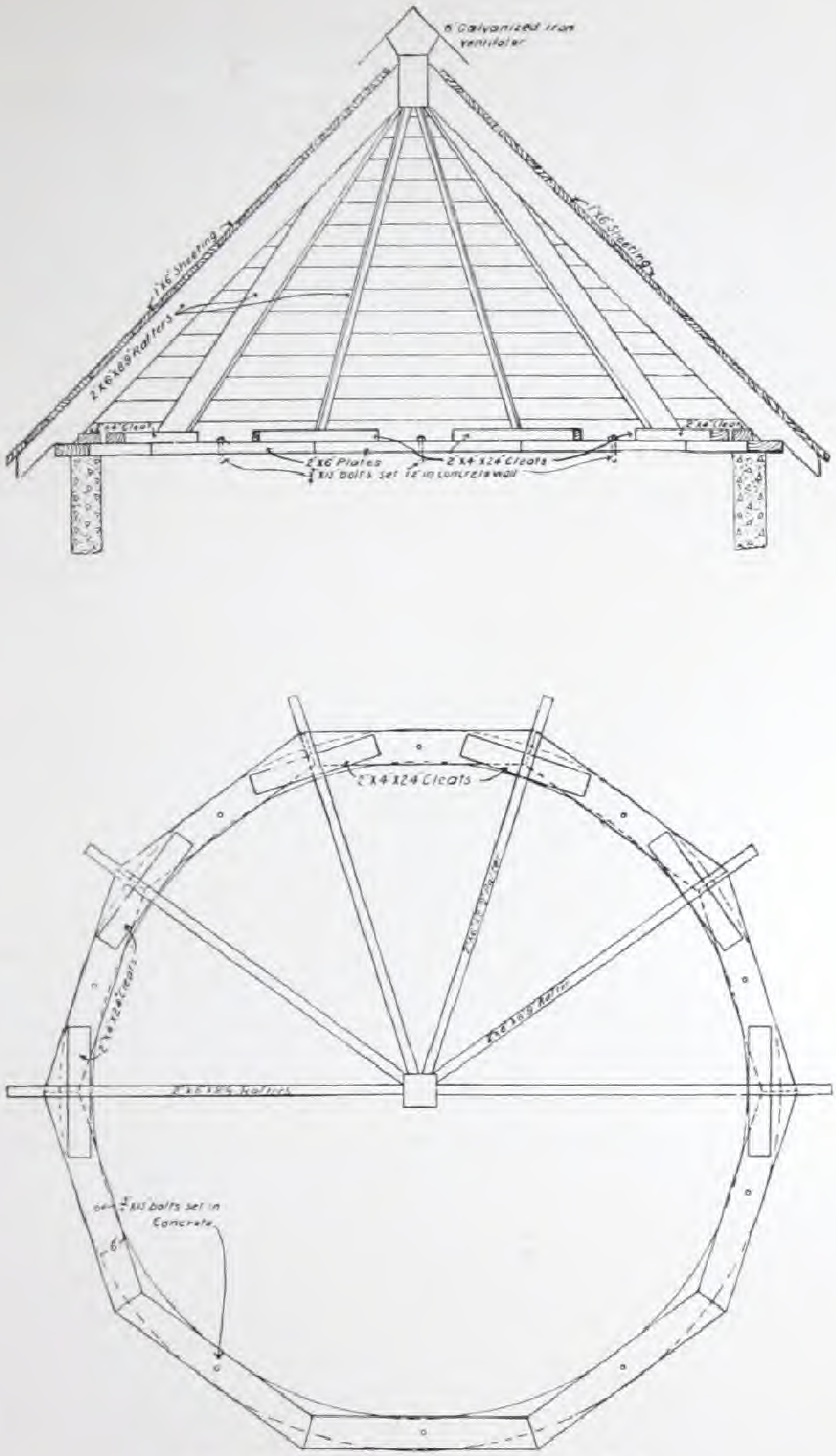


Fig. 113. Details of Suggested Wooden Roof.

Fig. 113 shows no roofing over the 1x6 inch sheeting. Either shingles or galvanized sheet-iron or tin may be used. During cold weather, stuff the opening between the roof and the roof plate full of old rags, paper, etc., to help prevent freezing.

Concrete blocks for silos are made in two ways—hollow and solid. In most instances silos are built of hollow blocks. The blocks may be made by the farmer himself, or he may buy them from a block manufacturer. If the blocks are bought, care must be taken to secure well-seasoned ones. That is, the blocks must have been made a sufficient time before using, at least sixty days, to give the cement time to thoroughly set. A good variety of block is shown on page 143, of which such a silo can be built as illustrated on page 122, while Fig. 116 illustrates a monolithic wall silo.

Every third course is reinforced with a ½ inch round iron embedded in grooves in the block. The blocks are laid in cement mortar, made in the proportion of 1 part Portland cement to 2 parts sand.

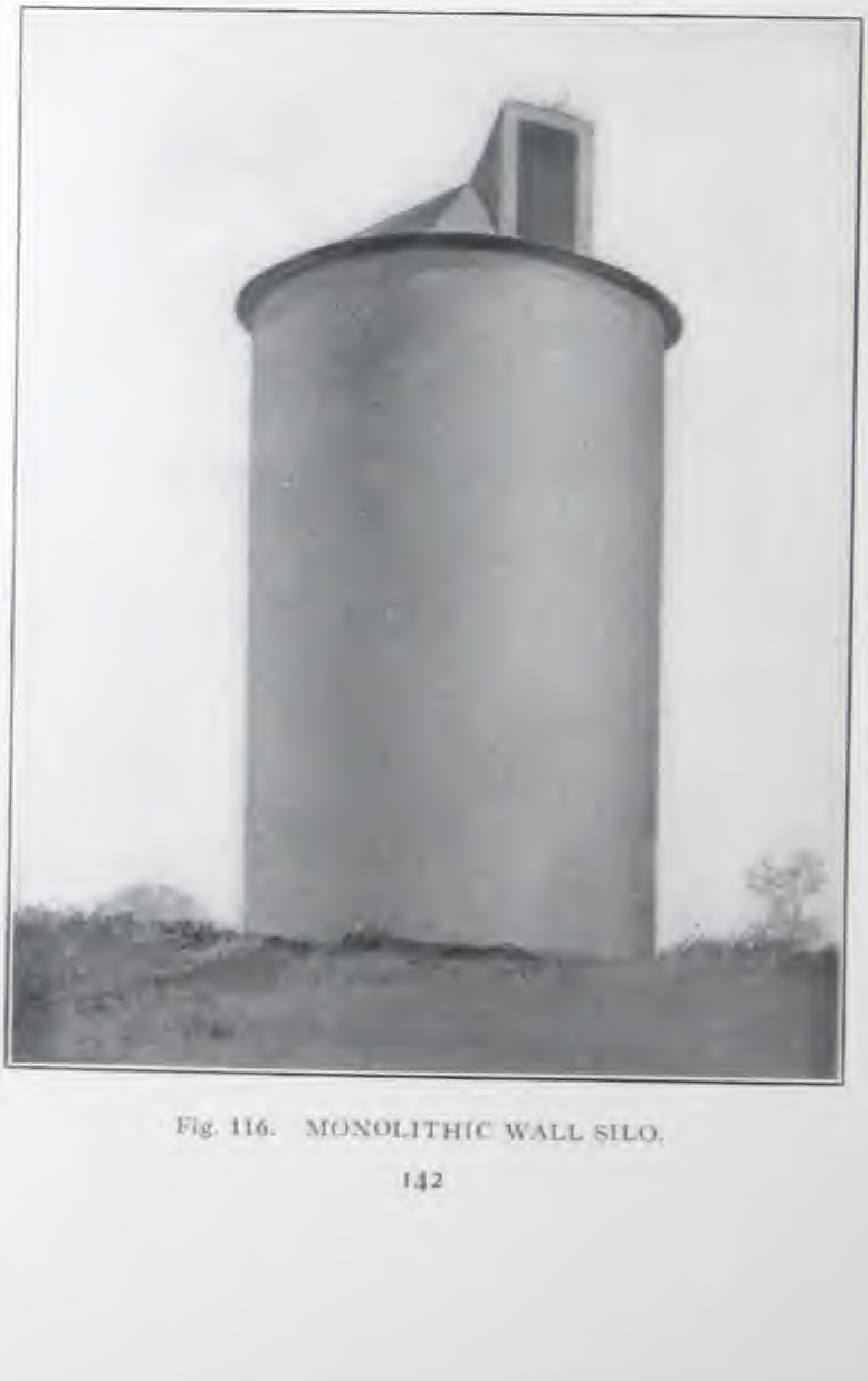


Fig. 116. MONOLITHIC WALL SILO.

GOOD TYPE OF CONCRETE BLOCK FOR SILO

CEMENT BLOCK RESIDENCE.
BLOCKS MADE OF AND LAID WITH "DRAGON" PORTLAND CEMENT

GRAIN ELEVATORS.

GRAIN elevators of immense size are now being constructed in concrete, and smaller ones for farm purposes can be readily adapted. For corn cribs, a great saving may be made in the waste from rats and mice, by constructing floors and foundations entirely of concrete.

GREENHOUSES.

CONCRETE is particularly well adapted for use in Greenhouse construction because it can readily be made impervious to the effects of moisture and obviates entirely the decay which takes place in wood because of warm temperature, high humidity and the alternate wetting and drying.

Fig. 117 shows how readily concrete walls can be applied in Greenhouse construction. They are not so liable to mildew and disintegration as brick walls.

Fig. 118 shows concrete used for the supports and boxes inside the greenhouse. Where such trays are employed, no metal linings are required and all the troubles with wooden ones are obviated.

Fig. 119 shows a concrete greenhouse with attached office and heater room, also of concrete.

FIG. 117. CONCRETE GREENHOUSE WALL.

Fig. 158. CONCRETE GREENHOUSE FLOWER BOXES

Fig. 159. CONCRETE GREENHOUSE

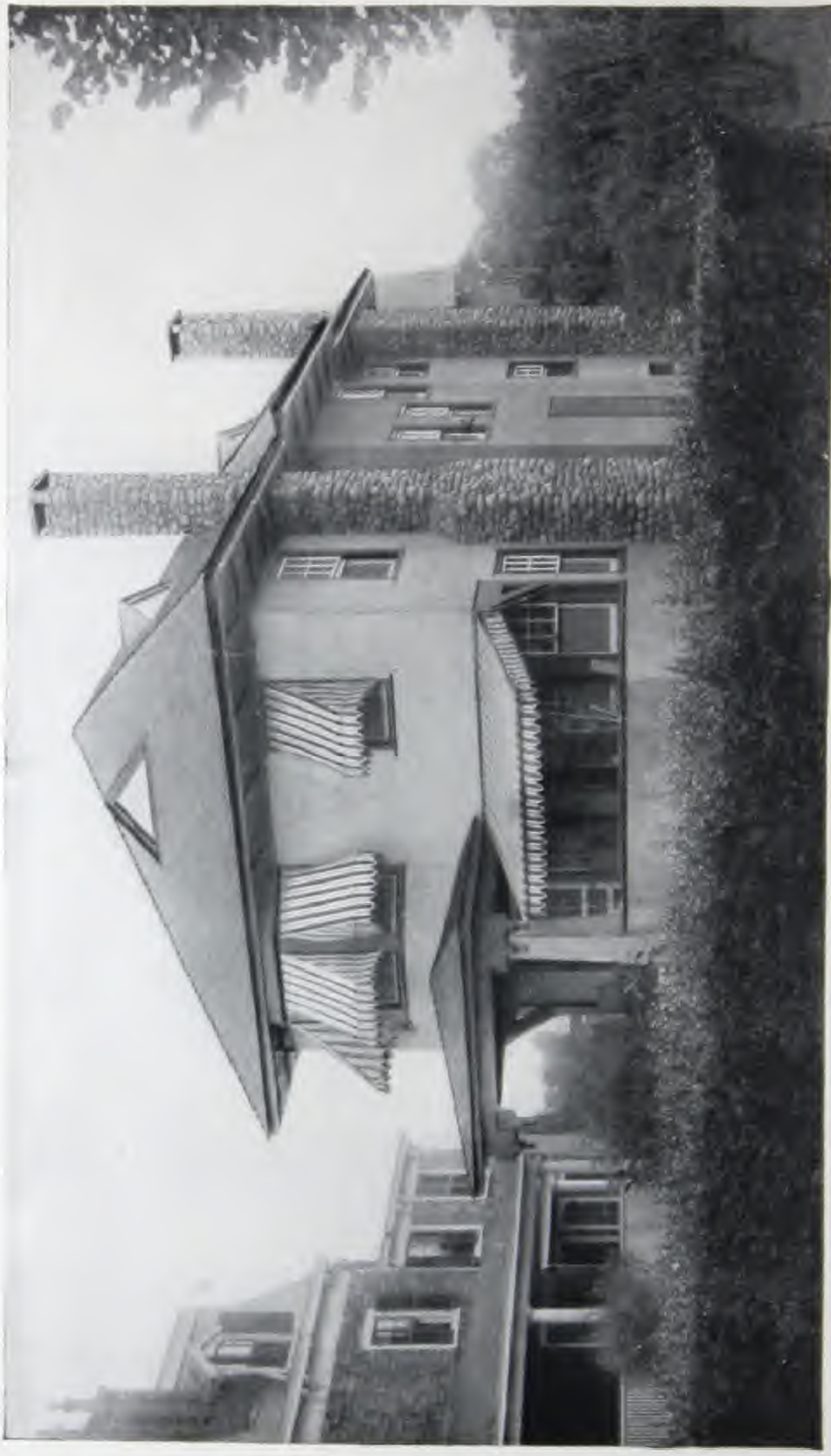
EXCELLENT EXAMPLES OF CEMENT HOUSES.

RESIDENCES.

IT WOULD seem very strange, now that concrete is becoming so well known, if the majority of those who own their homes did not turn to this most fireproof of all building materials to house the things which he most values on earth. The burning of one's dwelling often robs him of practically everything which he prizes, and is entirely incommensurate with the slight extra initial cost necessary to completely prevent such a catastrophe. Under ordinary circumstances, frame houses can be erected the most economically of any variety of construction materials. Under favorable conditions, however, builders have found that where cement was cheap and where the concrete aggregates were available at the cost only of handling, concrete cottages were erected more cheaply than frame ones. Certain houses near Pittsburg may be cited as examples.

Again, where stucco sides and tile or slate roofs are employed to prevent liability of catching fire from the outside, the costs of frame structures thus treated more closely approach those of a greater permanent nature and the possibility of using concrete throughout for floors and walls comes much nearer an economical condition than before. Especially is this the case when reductions in insurance rates are considered. Savings in fuel bills have been actually demonstrated where properly constructed concrete walls were involved.

Insurance rates can often be cut in half or the insurance on the building saved entirely, and while the yearly charge is not very heavy, saving it will pay the interest on a mortgage large enough to cover the cost of a very considerable improvement in the quality of the house. For example, if a frame house, to cost about $3000 is contemplated, and it is found that an insurance rate of 50c a hundred will be required, it is evident that the yearly expense will be $15.00. This is 6% on $250 which will go far toward paying for the extra cost of concrete. Now the cost of heating a small house will vary considerably, dependent upon its exposure and the local rates charged for coal and wood, but a reasonable estimate will hardly be less than $20.00. Simply the stuccoing of a frame house has been known to effect a saving of one quarter in the coal bills, which in this case would amount to five dollars. This equals six per cent on a mortgage of nearly $85, which when added to the $250 from the saving in the insurance makes $335. To this is to be added a small amount due to the saving which can be made because a periodic painting is unnecessary, etc. Finally, when it is considered that in a $3000 house, the cost of the walls and the floors does not aggregate more than $1000 to $1500, it is seen that an increased expense of nearly 33% in those items can judiciously be made without any additional yearly obligation or initial cash expenditure, and that the result is a considerably increased value in the property and an immeasurably increased immunity from loss by fire.



A GOOD CEMENT HOUSE.

When the builder originally considers the erection of walls of brick or stone, he will almost invariably find that he can secure the same general architectural effect by the use of concrete and at an actual monetary saving.

This has been the experience of many architects and builders, and when the possibility of combinations of stucco, and concrete or cement blocks for outside walls is considered, the brick or stone will almost invariably be found more expensive.

Certain objections have been urged against concrete walls and floors. The latter are considered cold and hard on the feet. These objections can be overcome by laying a regular hardwood floor over the concrete slab, the slab simply taking the place of the usual wooden floor joists. Sounds are conveyed very clearly when a single concrete slab is used for a floor with the top of the slab used as the wearing surface, and the ceiling plaster placed directly on the bottom of the concrete. With the use of a wooden floor surface and lath and plaster on furring for the ceilings, this objection is entirely eliminated.

Concrete walls are considered cold and either allow moisture to pass through them or to condense on the surface and prove equally objectionable under certain atmospheric conditions. These troubles may be entirely obviated by the use of furring with lath and plaster on the inside faces of the side walls and by the application of a waterproofing on the outside.

CEMENT COTTAGE

A CONSISTENT DESIGN FOR A CEMENT HOUSE

When concrete is used for floors, the designer should be careful to arrange his supports and openings so as to make the system of reinforcement required as simple and economical as possible. Not all designs are adapted to ready construction in concrete and all should be submitted to some one who has had a number of years experience in this line of work if a particularly economical design is essential.

Similarly, solid concrete walls should have reinforcement properly distributed through them to prevent shrinkage cracks.

From the contractor's point of view, the general arrangement of angles, projections, wall openings, etc., should be as simple as possible so that the form work may not be expensive.

With an experienced architect or engineer and an expert contractor, houses of concrete are now possible of as intricate and artistic a nature as an owner may desire. On page 149 is shown a very simple cottage which was erected by the owner, a good mechanic, with the help of a few of his friends and has been found to have cost less than a frame structure.

Excellent designs of attractive concrete architecture are illustrated on pages 146, 148, 150 and 152 showing monolithic work and walls built of cement blocks in a very pleasing manner.

RESIDENCE OF WILLIAM BUCKHOLTZ, LA VALE, CUMBERLAND, MD.
BLOCKS MADE AND LAID WITH "DRAGON" PORTLAND CEMENT.

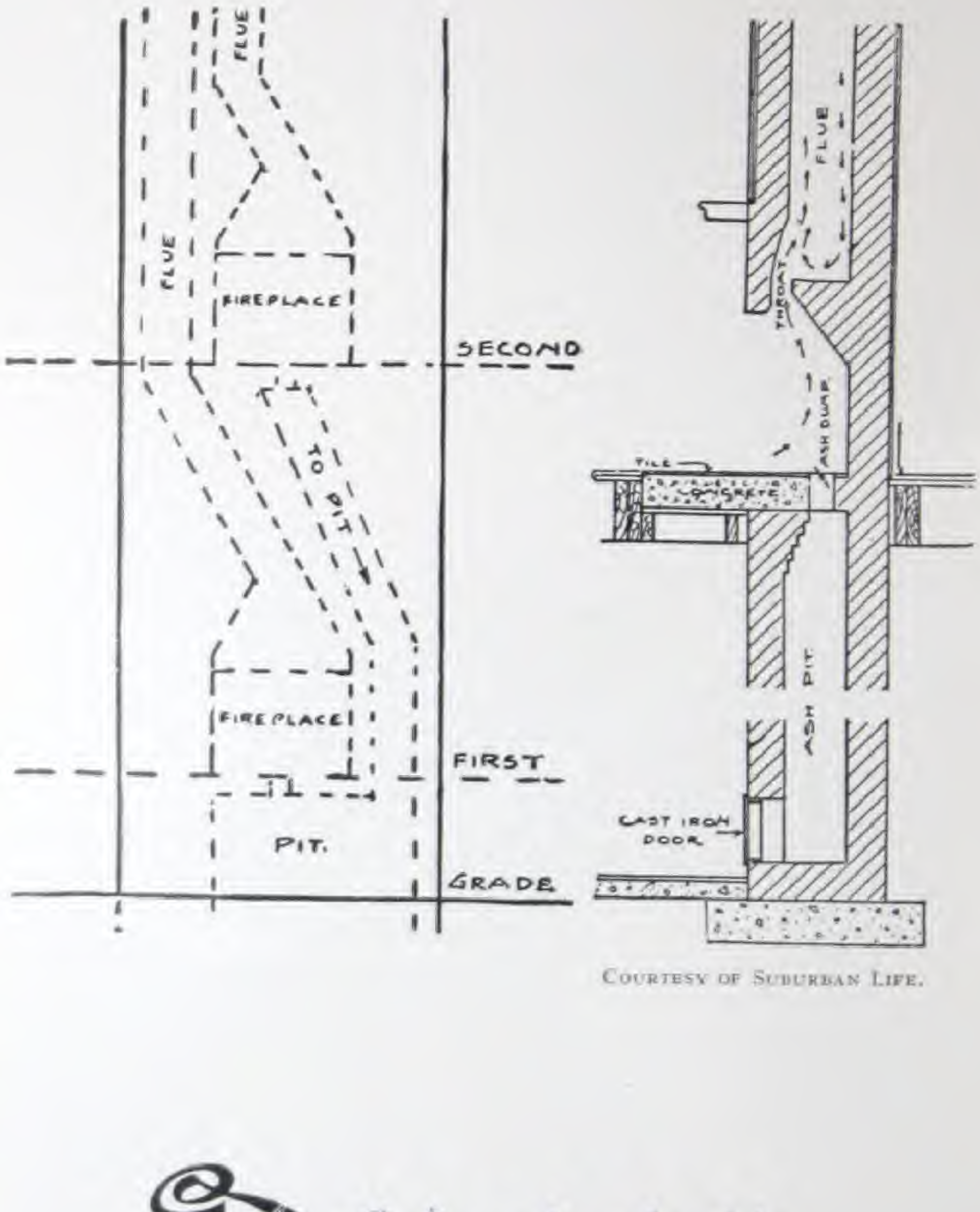
FIREPLACES & CHIMNEYS.

MOST artistic and serviceable fireplaces can be constructed in concrete, either in mass or built of cement-brick or concrete blocks. No fire-brick are required for the lining, as good Portland Cement when thoroughly set will resist very intense heat. In a country home or farm house, a fire place of the old-fashioned variety is a most delightful adjunct to a long winter evening. The chimney and chimney cap may also be of concrete, the chimney either of mass concrete or erected of blocks, while the cap should always be one large block which can be most easily molded in place. Ample foundations should be provided for the chimney, and should be made hollow with a large sheet iron door leading from this hollow space. Into this hollow bottom one flue of the chimney should lead so that the heat from the fire place back will cause a natural draught up this flue and thus aid in preventing a smoky chimney. A flue should also be carried independently from this hollow space up under each hearth in which should be placed a trap door down through which to run the ashes. This will prevent the dust and trouble incident to removing them through the living rooms. Up through the chimney, a separate flue should be carried from each fireplace. For an ordinary fireplace with a front opening three feet wide and two and one-half feet high with a depth of twelve inches, these flues can be twelve inches by eight inches. For a fireplace which will take a four foot log the flue should be twelve by twelve inches. For the hearth and the inside of the fireplace, brick will be better than mass work, because the natural joints will provide opportunities for the expansion and contraction caused by the changes in temperature which would otherwise cause unsightly cracking.

The dimensions of some fire-places actually thus constructed are as follows:

Height of opening	26 - 30 - 28 inches
Width of opening	34 - 44 - 31 "
Width at back	28 - 28 - 24 "
Width of hearth	20 - 26 - 16 "
Depth of fire-place	16 - 22 - 16 "

These figures give diagrams of how to build a chimney that will not smoke.



COURTESY OF SUBURBAN LIFE.

GARAGES.

THE high inflammability of oil and gasoline makes a fireproof structure for the storage and over-hauling of automobiles a practical necessity. Nothing can be superior to concrete for this purpose.

The garage can be made as simple or as complicated as is desired. It may be combined with another building, like the stable or tool house, or even occupy a portion of the basement of a residence, if the latter is built of reinforced concrete, and if the conditions are such as to admit of ready access from the outside. If the garage is to be of a more pretentious nature, it may have incorporated with it in the second story or in an annex a small apartment for the chauffeur and his family.

Obviously the structure may be erected to accommodate as many machines as is desirable, but where several are housed in the same building, it is highly preferable to have them separated by fireproof partitions to prevent heavy damage in case of accident to one of them by fire. Unless a turn table is installed or a considerable space provided for turning, it is best to have a separate exit for each car.

Ample light both natural and artificial should be provided for the purpose of repair, and where any considerable amount of overhauling has to be done in the garage, it is often found convenient to have the construction over the main floor so heavy in character as to be available for attachment of means for hoisting heavy parts of the machines. The large machine of modern type, requires a width of at least 10 feet and a length of 20 feet, and head room amounting to 10 feet should be provided.

Fig. 120. SIMPLE GARAGE FOR ONE AUTO.
COURTESY OF SUBURBAN LIFE.

The first floor should be directly on the ground so as to give ample strength for jacking up parts of the machines. It can be constructed exactly like a sidewalk, and should not usually be less than six inches in thickness. Top surfaces should be carefully finished and preferably coated with a waterproof floor finish, so that oil and water will not be absorbed by the concrete. It should be given a proper slope to drains placed beneath the floor with outlets at convenient points. Almost invariably the room should be provided with heat for the winter, and the whole structure finished in a careful, consistent manner. It is usually wise to build in bars at the windows and to provide each large door with heavy fastenings, and a special lock, each of a different character. One small door should be provided for use, only large enough for persons, and where the garage is built in connection with the main house, or has rooms for the accommodation of the chauffeur's family in connection with it, this small entrance of the garage proper should be located so as to communicate through the other parts of the building.

Tanks for gasoline, kerosene, lubricating and other oils are best buried in the ground at some distance from the building, all communication with them being secured simply by pipes and pumps, which latter should always be located in a place provided with ample light so as to be able to detect any drip or leakage.

Fig. 120 shows the exterior of a simple structure for the housing of a single machine while Fig. 121 shows a much larger building.

Fig. 121. GARAGE STABLE AND COTTAGE COMBINED.

FINISHING CONCRETE SURFACES.

IN all superstructural concrete work, a certain degree of artistic treatment is involved. This very largely takes the shape of panels, moldings, projections, pilasters, belt courses, balconies, etc., but surface finish also must be considered in all but the simplest structures. The uniformity and dullness of natural concrete surfaces is not pleasing to most persons, so that many architects and constructors make use of variations in color, as well as of special surface treatment.

The wet concrete, which is now most often employed, is so very plastic that it shows in the minutest detail the peculiarities of the molds in which it is formed. Necessarily, therefore, imperfections in these molds are to be carefully avoided and only such molds selected as will give surfaces which are pleasing in appearance. Forms which are imperfectly constructed with different thicknesses of lumber used indiscriminately, or with dirt or old cement adhering to their surfaces, will not produce results which are compatible with ordinary conditions. Where it becomes necessary to secure perfect surfaces as they leave the forms, the latter should be constructed of narrow, matched lumber, at least one inch and a quarter thick, carefully braced so as to prevent bulging and thoroughly washed immediately before fresh concrete is deposited. Joints should be carefully filled with clay and the grain marks can be reduced to some extent by oiling the lumber and then throwing fine sand against the oiled surface. With careful construction, very elaborate moldings, intaglio work, etc., can be produced, but such work is costly, since the carpenter work has to be equal to the best cabinet work or pattern making. Very beautiful results, however, can be obtained where cost is not an item.

With this form of treatment, the surface is always extremely smooth and unless treated in color, is apt to be somewhat monotonous. Many people prefer a rougher condition. Several methods are employed of securing such results. Sand blasting is very effective and, if carefully done by an expert, can be made to produce panels, belts, etc., and the effect of the blast can be carried as deeply as desired. With a slight cutting of the surface, the appearance of sandstone is obtained. Deeper cutting will remove more of the mortar which has been flushed against the forms and the aggregate will be exposed. By a proper selection of the various ingredients entering into the original mixture, variations in surface and even in color are obtainable, if the surface is sand blasted or otherwise treated, so as to reveal these aggregates. Broken brick, white marble chips, blue trap rock, other colored marbles, etc., together with the gray matrix of the cement mortar, can be combined to give almost any desired combination of colors and surface effects. White pebbles of various sizes can be employed and the aggregate may be anything from the size of coarse sand to that of pieces an

THIS ILLUSTRATION SHOWS THE USE OF CONCRETE TO PROTECT AND RE-INFORCE OLD STONE WORK.

inch or more in diameter. Obviously, if special effects are desired with this course of treatment the concrete must be deposited with exceptional care.

Instead of sand blasting, the concrete surface may be scrubbed with water and ordinary scrub brushes, if the concrete is not allowed to get too old and hard. Water should be freely used from a hose and the amount of force exerted will give as deep a cutting effect as desired. Older concrete may be similarly treated by etching with acid. This may be either sulphuric, hydrochloric or acetic. The concrete work should be deposited in a fairly dry mixture if acid is eventually to be used. The acid should be neutralized with an alkaline solution and finally well soaked with water (this acid treatment is covered by patents).

Less vigorous treatment can be secured by wetting and rubbing the surface with a block of hard-wood, old concrete, sandstone, or carborundum, or scrubbing with a stiff, wire brush, but in each instance the concrete must not have attained too great an age. A vigorous use of water is also advisable. Other textures of surface may be obtained by tooling with pneumatic tools or by hand. The concrete should be very hard for this method of handling, and when care has been taken with the forms and in the placing of the concrete, effects practically identical with those of natural stone can be produced. Bush hammering is the most popular method, while other forms of finish have also been employed. All the exterior surfaces of the Connecticut Avenue Bridge in Washington were thus treated. Unless form lumber which is of absolutely uniform thickness is employed, it becomes necessary to tool some parts of the surface deeper than others. This variable depth of tooling produces differences in the surface which are objectionable, so that care should be exercised in the construction of the forms in regard to this point, although they may be constructed of rough lumber if more convenient.

The use of rough lumber and a very dry mixture carefully rammed will also give a surface pleasing under certain circumstances.

Almost any special variety of treatment and of any degree of intricacy can be secured by the use of stucco. Obviously the stucco may be of any color, texture and finish. But it must be firmly bonded to the backing and very carefully applied. Smooth finished stucco work is apt to develop fine hair cracks, and is consequently objectionable. These cracks are also usually discovered in other varieties of surface, but with slap-dash and pebble-dash work they are practically invisible. Some workmen allow the stucco to become partially set and re-temper it in an endeavor to obviate this surface crazing, as it is called. Moldings and heavy work of other kinds must be built up little by little, each layer carefully applied and fully hardened before the next one is installed. It is much easier to produce color effects by employment of stucco than by endeavoring to employ colored cement or some coloring compound in the mortar of the mass concrete work. Either

THE CONNECTICUT AVENUE BRIDGE AT WASHINGTON, D. C
"DRAGON" PORTLAND CEMENT USED EXCLUSIVELY.

for stucco or mass work, however, the following materials have been successfully employed:

Buff stone Color: Use 8 parts by weight of yellow oxide of iron, 1 part red oxide and 36 parts cement.

Red: 87 parts cement, 11 parts red oxide of iron, 2 parts black oxide of iron or copper.

Yellow: 84 parts cement, 14 parts yellow oxide of iron, 2 parts black oxide of iron or copper.

Caen Stone Color: 4 parts yellow oxide of iron, ½ part red oxide, 36 parts cement.

Blue: 80 parts cement, 18 parts azure blue or ultramarine, 2 parts black oxide of iron or copper.

Green: 85 parts cement, 12 parts oxide of chromium, 3 parts black, oxide of iron or copper.

Chocolate: 88 parts cement, 6 parts black oxide of manganese, 4 parts red oxide of iron, 2 parts black oxide of iron or copper.

Black: 87 parts Portland cement, 13 parts black oxide of manganese or any carbon black.

White: 67 parts cement, 33 parts sulphite of barytes.

Only those colors should be employed which consist of the oxides of the various materials, since the salts are all liable to disintegration. Even colors thus obtained appear to fade in the course of years to some extent. In mixing the ingredients, the greatest care and exactitude are essential. If improperly mixed, the surfaces are apt to be spotty. In deciding upon a tint, specimens containing different proportions of the coloring matter and of cement should be made and allowed to become quite dry before observation.

More satisfactory methods of securing color are by the employment of brick or tile embedded in the concrete surface. Very striking effects, with regard to quoins, lintels, belt courses, etc., can be secured by the use of red brick in combination with concrete for pilasters, sill courses, etc. Occasionally, curtain walls under windows, etc., are constructed in red or buff brick with good effect. If the brick are embedded in the mass concrete work as the latter is carried on, a rather dry mixture should be used, and in order to maintain the exact positions of the several pieces, joints should be maintained by the use of wooden wedges and strips. Tile, either glazed or unglazed, and of any degree of intricacy of design as to shape and color, can be employed. The pieces may first be glued to perforated forms with common bill posters' paste, and the mass concrete deposited as usual. When the concrete is properly set, deluging the forms with water will dissolve the paste so as to allow the removal of the molds. Such tile work can also be cast in the form of slabs to be set in recesses molded in the mass concrete work, if this method is found more economical than placing the tile in the molds for the original surface. When the latter course is employed, copper tacks

39TH STREET (McGRAW) BUILDING, 239 W. 39th ST., NEW YORK CITY.
STUCCOED ON CONCRETE
DRAGON CEMENT USED EXCLUSIVELY

Fig. 125. STUCCO WORK ON CONCRETE.

are sometimes used to secure the tile to the centering, no discoloration from rust taking place with the lapse of time where copper has been used. Mosaics, the soffits of domes, belt courses around columns or along facades, ornamental medallions and innumerable other points have been beautifully ornamented by this means. In a sense, one becomes a painter using clay paint. The breadth of design, width of line, etc., must obviously be proportioned to the distance of the observer from the ornament.

Bronze, copper or painted pressed metal, can also be employed to any extent required to give color and ornamental effect to concrete work. Light iron grilles, balconies, etc., are very effective in combination with concrete work, but all metal when so used must be absolutely prevented from corroding, or otherwise the concrete surface will be stained so as to become immediately very unsightly. Blocks of mortar or concrete made with fine aggregate, can be planed, sawed, or turned with machines just as the softer quarried stones are handled.

The 39th Street Building is an example of stucco on mass concrete with painted metal panels to give a touch of color. The ornamental concrete work was cast in molds and afterward set in recesses left in the mass concrete.

Fig. 125 shows some of the possibilities of stucco work. The columns of this building were built of gravel concrete while the walls between were of cinder concrete. Over the whole surface was spread a stucco coat. The columns

Fig. 126. OLD STONE CHURCH WITH STUCCO REPAIRS.

and moldings were finished smooth while the panels between were made rough.

The walls of the old stone church shown in Fig. 126 were disintegrating so badly that a stucco finish of Dragon Cement was applied which has effected a permanent and artistic remedy.

Figs. 127 and 128 show a small building erected of Dragon Cement concrete actually for a railroad signal tower, but from its artistic design and finish might be used for almost any high class structure. The progress picture illustrates how the wall forms were erected, held by bolts through the walls exactly as described under the subject of forms. The surface was finished by rubbing with water and then brushing on and rubbing in a coat of cement grout.

Returning to the subject of surface finishing in general and of stucco in particular, there are four general schemes for finishing the exterior of a frame house:

1. Clapboards over building paper with or without weatherboards nailed on the studding.

2. Shingles over building paper with or without weatherboards nailed on the studding.

3. Cement stucco on metal lath fastened to furring strips over building paper with or without weatherboards.

4. Cement stucco on metal lath fastened direct to the studding with an extra coat of cement mortar on the inside of the metal lath between the studs.

Fig. 127. SHOWING POSSIBILITIES OF ELEGANCE FOR CONCRETE STRUCTURES.

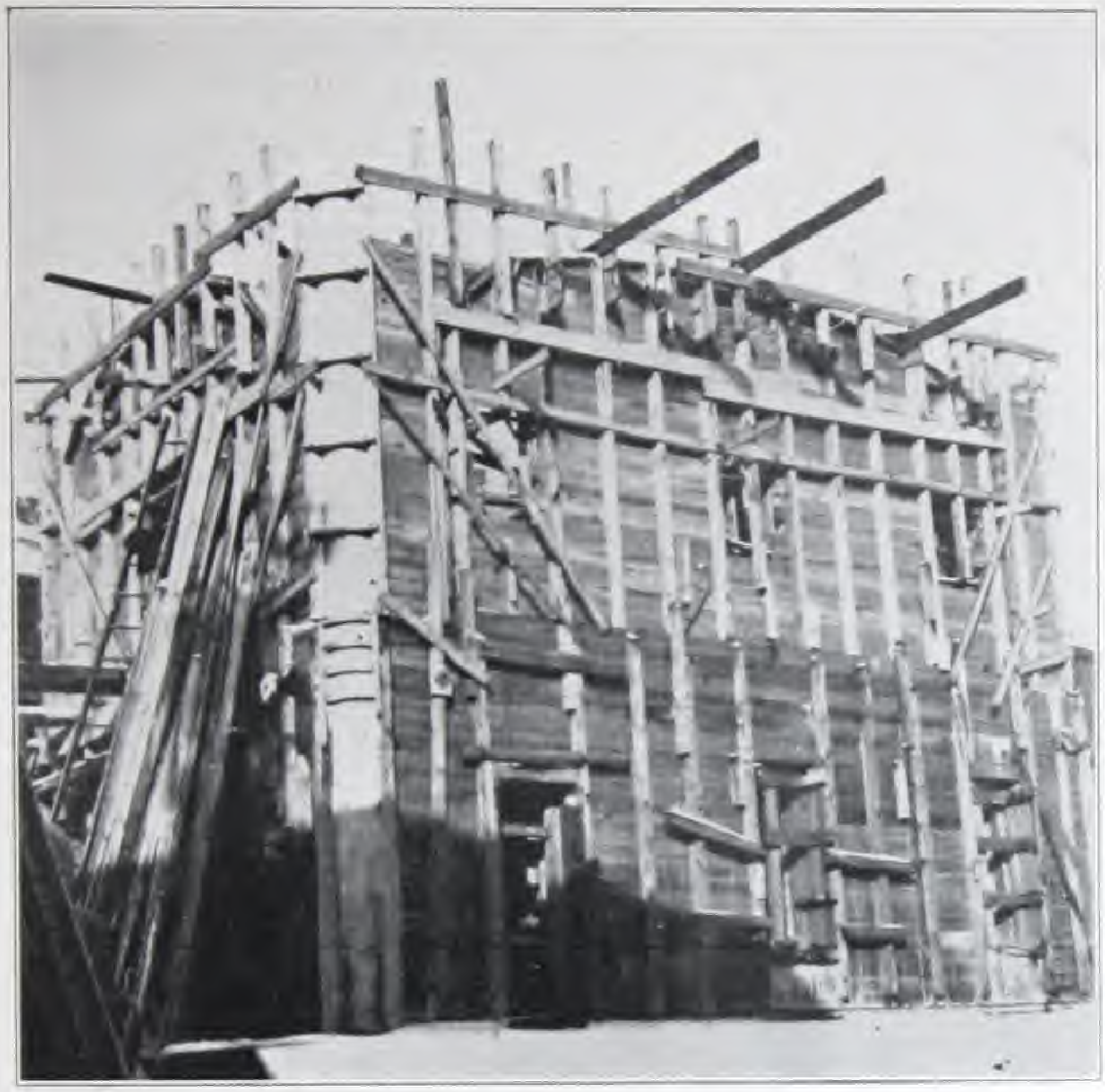


Fig. 128. WOODEN WALL PANEL FORMS HELD BY BOLTS.

The stucco should be made of five parts of Portland Cement, twelve parts of good coarse plaster sand, and three parts of well slaked lime putty, with a small quantity of real hair for the first coat; and a finishing coat made of 1 part Portland Cement, about 3 parts clean plaster sand, and one part slaked lime putty. This should be applied by a mason experienced in stucco work. A house plasterer has seldom had the right experience. The lime should be completely slaked, as trouble will surely result if it is not. Some masons prefer to omit the lime, but the work costs more because it cannot be applied so rapidly. Some workmen apply the first or scratch coat about ½ inch thick pressing it well through the openings in the lath, and just before it is set roughen the surface with a stick, or trowel. Others prefer to apply the first coat somewhat heavier and bring it to a perfectly even surface by means of a float. In the first case the top coat should be a half inch thick and carefully smoothed. In the second case the trueness of finish is secured with a very thin coat just as a thin hard-plaster coat is secured. The surface effect is obtained by using different kinds of finishing tools. A

metal trowel is seldom employed, as fine cracks are more apt to become visible. A wooden float is often used and leaves what is called a sand finish. A heavy sponge tapped lightly on the fresh mortar gives a rougher finish much used, while in other kinds of work different effects are secured by throwing on the material with a trowel or stiff brush. This is called slap-dash or spatter-dash work. A different texture of surface in effect can be secured by mixing with the top coat, pebbles of ¼ inch diameter or larger and throwing on the material from a trowel. Sometimes the pebbles are thrown against the plastic surface from the hand, or where specially fine work is desired, larger pebbles are employed and each individual stone placed where it is desired it should be. The surface can finally be treated with a cement wash or with one of the many cement coatings in almost any color, which are now on the market.

METAL LATH.—Such work, unless specially treated, is not usually impervious to moisture and metal lath has been known to rust away so that the stucco fell off in large masses. All sorts of promises are made by salesmen with regard to the protection afforded by their product, but before using any one, its history for several years should be investigated. The metal lath must be of good weight and securely fastened. An inside coat of cement plaster adds weight on the lath, is more apt to produce dry rot in the studding and is not likely to make as warm a job as when boards and paper are used. Obviously much more variety is possible when stucco is used than when shingles are employed and their periodical painting is not necessary.

If the extra money can be spent, it is strongly recommended that the walls be built of cement blocks, if stucco is to be used; instead of using a wood frame. There is then no metal lath to rust out and the walls at least are fireproof.

CONCRETE TREE CHIMNEY.

COURTESY OF "CEMENT AGE."

LAWN ORNAMENTS.

CEMENT concrete lends itself particularly well to the construction of decorative features of various kinds. The ornamental possibilities of concrete, especially when reinforced, are very great. Molded fountains of cement concrete can be erected of the most complicated and beautiful sort. Settees, or benches of reinforced concrete can be readily constructed as complicated and artistic as desired, while some crude products which would be equally as serviceable, can be made of mass concrete at much less expense.

Fig. 130 shows a jardiniere made in a sand mold. Standard metal molds are manufactured for certain lines of work like fence post caps, porch columns, railings, etc. Another method of work consists of modeling with cement mortar exactly as a sculptor works with clay. Fig. 131 shows a fountain basin with a woodland scene thus molded behind the front, which represents a brook issuing from a forest.

Fig. 130. JARDINIERE OF CEMENT IN SAND MOLD.

Fig. 131. FOUNTAIN BASIN OF CEMENT.

Fig. 132

Fig. 132 shows a piece of work in high relief done in the same way, while Fig. 133 shows one end of a concrete seat with an animal form molded as one arm. Fig. 134 shows similar figures used for gate post caps and Fig. 135 is a reproduction showing a life size bird modeled in this way erected in a most effective spot. Fig. 136 shows a bird house molded of cement. Fig. 137 shows two seats built of concrete and placed, one each side of an entrance. For those who desire and admire this class of work cement affords unexcelled opportunities.

Fig. 138 shows a Park resting place in the form of a pergola, erected entirely of concrete, illustrating the possibilities in this type of construction. Note the steps, the paneled railings, the columns, and overhead beams.

ROLLERS.—For the preparation of tennis courts, croquet courts, golf greens, etc., and also in the maintenance of a fine lawn, a heavy roller is indispensable. Figure 139 shows three made of concrete. They can be easily molded in forms similar to those for the outside of cement pipe. It is necessary only to put in place through the center a piece of gas pipe to form the hole through which to pass the axle. The handles can also be formed of the same material, with T's, L's and caps properly screwed together. The only blacksmith work required is in arranging the axle which is simply a rod with ends battered over so that the rod will not slip through the holes in the two side pieces. A roller 16 inches in diameter and 2 feet long will weigh about 250 pounds and will require a bag of cement to make it. Those in the illustration were made with Dragon Portland. While the concrete is still fresh from the forms, the outside may be rubbed down if necessary to produce a perfectly smooth cylindrical surface.

Fig. 133. CONCRETE SEAT WITH MOLDED ANIMAL.

Fig. 134. GATE POST CAP FIGURES IN CEMENT.

Fig. 136. BIRD HOUSE OF CONCRETE

Fig. 135. MOLDED IN CEMENT.

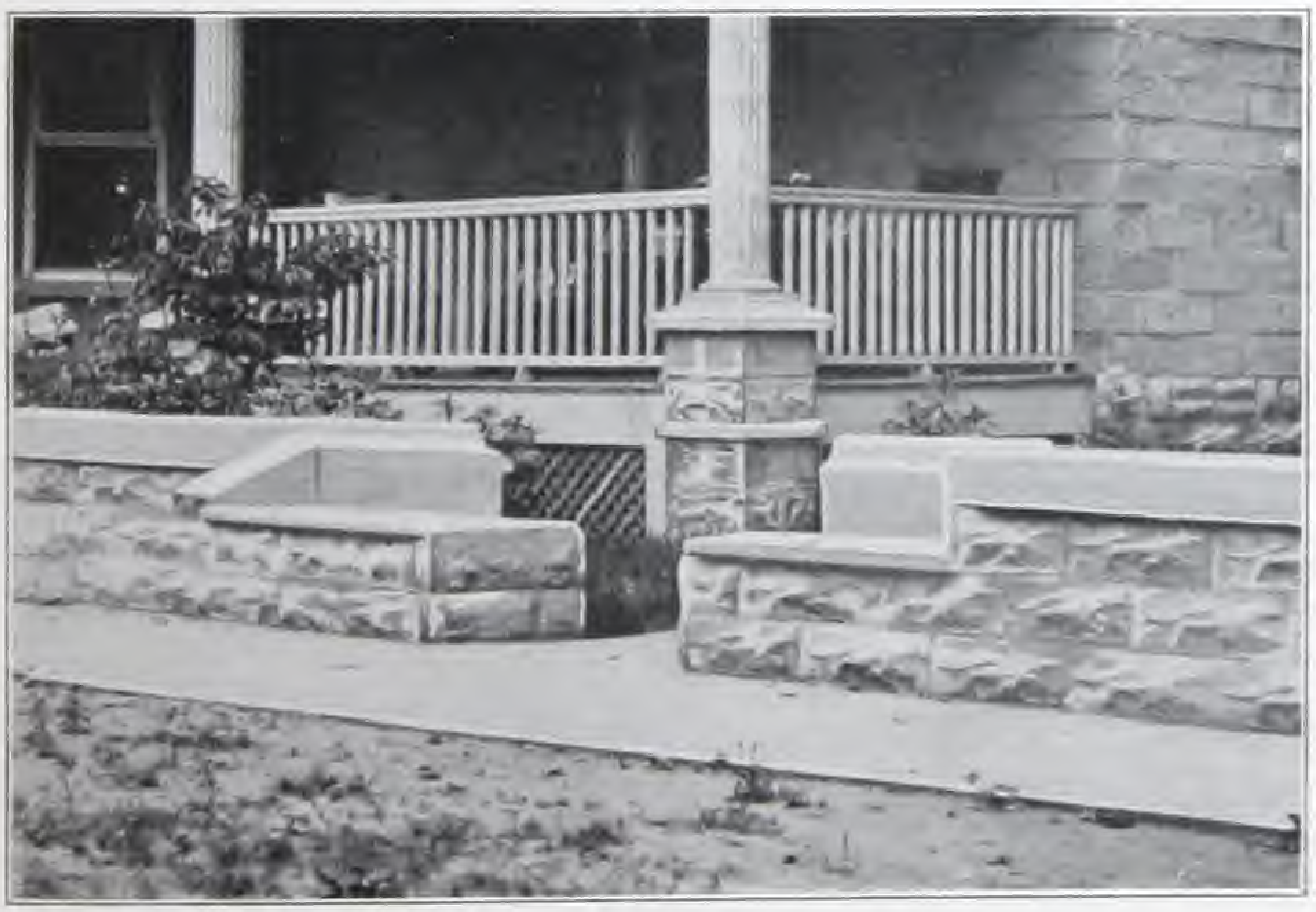


Fig. 137. CONCRETE SEATS AT ENTRANCE WALK.

Fig 138. PARK PERGOLA OF CONCRETE.

Fig. 139. LAWN ROLLERS AND ARBOR POSTS IN CONCRETE.

Fig. 140. DRINKING FOUNTAIN MOLDED IN CEMENT.

Fig. 141. GARBAGE RECEPTACLE OF CONCRETE.

Fig. 140 represents a drinking fountain under cover. This is of great ornateness of design showing that there is almost no limit to the variety of work to be accomplished with cement.

Fig. 141 shows a form of receptacle for paper, fruit skins, etc., which is being used in some of our parks. The opening at the bottom serves for the removal of the refuse with a small rake.

The molding of the outside to imitate a stump is in excellent keeping with the surroundings and is in exact line with the effort made by a Frenchman to disguise a chimney which had to be erected on his estate, by making it of concrete with the outside molded in imitation of the bark of a tree like which it was also colored. This concrete tree-chimney is illustrated on page 167.

CONCRETE COLUMN OF DRAGON CEMENT.

FOUNTAIN BASINS.

TO construct a fountain basin of concrete, first make an excavation of the desired shape, and fill partially with a six inch layer of ashes or loose gravel. The pipes through which water is to be admitted and drained away, are to be carefully installed in this sub-base. The intake pipes should be of galvanized iron, and supplied with a flange located about three inches above the surface of this preliminary fill. The drain pipe can be of terra cotta, but it should be glazed material with cemented joints, and be led to a proper outlet, so as to prevent water collecting under the fountain basin.

Upon the sub-base a concrete foundation should be laid exactly as described for a sidewalk, except that no joints should be made, and it is wisest to employ reinforcement consisting of ¼ inch rods laid about 9 inches apart in two directions at right angles, and carefully embedded in the concrete base. This base should be finished with a cement surface, exactly like that of a sidewalk, and a curb of proper height and design should be erected around the edge of the fountain exactly as heretofore described. It is a wise precaution to locate in this curb a continuous ½ inch rod at its centre, which would prevent expansion and contraction cracks. As shown by the illustrations very effective designs can be worked out in concrete in this way.

CONCRETE BOTTOM FOR PARK LAKE.

A basin for a spring can be constructed with basin and curb in a manner very similar to that described for a fountain basin. For the inlet pipe it is best to use a piece of terra cotta pipe sunk around the point of flow. This terra cotta pipe can then have a pump suction in it and the water thus kept down while the concrete is being placed. Unless an outlet pipe is located so as to extend down through the concrete bottom and away through a buried drain, an overflow must be molded in or through the curb around the basin, but the water should be carried off in a trough to prevent a constant muddy condition, which the concreting of the spring is especially designed to prevent.

By the picture on page 177, it is seen how a small lake in a park or on an estate can be given a concrete bottom to prevent the growth of aquatic vegetation, etc.

CONCRETE BLOCKS.

HOLLOW concrete building-blocks properly made and used, form an ideal material for the exterior walls of many buildings. The concrete replaces that part of a structure which if built of wood, rapidly deteriorates from exposure to the weather. Buildings constructed of such blocks should be as reasonable in first cost as if built of frame, and they are much less expensive for maintenance. They have all the advantages of brick and stone in point of comfort, namely, coolness in summer and warmth in winter. Concrete blocks are ideal for all out buildings, and when coated on the exterior with stucco or cement plaster, they make as artistic a structure as the inclination of the builder may dictate. Concrete blocks can readily be made on the farm or country estate during rainy days or when men are otherwise idle, and after several thousand blocks have been made and thoroughly hardened, a mason can very rapidly erect the walls of any small building and the owner is put to very little expense compared with the cost of wooden structures.

COMPONENT PARTS.—In selecting materials for concrete blocks only those should be chosen which will produce a mixture of the greatest possible density. This fact should be determined by experiment, mixing available samples of cement, sand and gravel in varying proportions and finding of which combination, a level pail full weighs the most. The result thus obtained should be carefully followed in proportioning mixtures for all subsequent work. A considerable proportion of coarse material is just as necessary for concrete blocks as in other kinds of concrete work, and gravel or stone screens should be employed to secure such materials unless they can be obtained in a natural state.

PROPORTIONING.—There are four important points which must be kept in view in adjusting the proportions of materials for block concrete, namely,—endurance, strength, impermeability to moisture, and cost. 1. The endurance depends primarily upon the cement employed, although certain qualities of sand and certain materials in the water employed sometimes cause trouble. 2. As to strength, it is doubtful whether blocks of satisfactory quality can be made under ordinary conditions by hand, from a weaker

mixture than 1 cement to 5 sand and gravel. The amount of water to be used is a matter of the utmost importance and has more effect on the quality and strength of the blocks than is generally supposed. Blocks made from very dry concrete will always remain soft and weak, no matter how thoroughly sprinkled they may be afterward. On the other hand, if the blocks are to be removed from the machines as soon as they are molded, too much water will cause them to stick to the plates and sag out of shape. It is quite possible, however, to proportion the water so as to secure high density and good hardening properties and still be able to remove the blocks at once from the molds. A large proportion of coarse material allows the mixture to be made proportionately wetter without sticking or sagging. The general rule to be followed is: Use as much water as possible without causing the blocks to stick to the plates or change shape on being removed from the machine.

This amount of water varies with different materials but is generally slightly less than 10% of the weight of the dry material, and an experienced manufacturer can judge accurately when the right amount of water has been employed by squeezing some of the mixture in his hand. Slight variations in the proportion of water make a marked difference in the quality and color of the blocks, so that when the proper quantity has been determined for any set of materials, that quantity should always be accurately measured out for each batch. Materials should be mixed in the dry state until the combination is uniform in color and the parts are perfectly combined. Then the water is to be added and the mixing continued until all the parts are equally moist and every particle is coated with cement.

TAMPING AND SEASONING.—Tamping must be conscientious and thorough. It is best that the mold be filled layer by layer, carefully tamping each addition but not so as to produce lines of stratification. At least four such fillings and tampings should be given each block. Blocks should not be used in buildings earlier than four weeks from the day on which they were made. During this period of seasoning, blocks will be found to shrink about 1/16 inch in length. This shrinkage would cause cracks in any finished structure erected with green blocks. Hardening or seasoning of blocks should be done under a roof where they are not subject to draughts or to direct light or wind. Watering should be done regularly and in proper amount. Efflorescence or the appearance of a white coating on a block sometimes takes place when it is occasionally sprinkled and allowed to get dried out between wettings. Blocks placed directly on the ground are most liable to show this defect.

IMPERMEABILITY.—The chief fault of ordinary concrete building blocks is their tendency to absorb water. They are, however, generally no worse than common brick and some kinds of stone. Brick and stone walls, unless especially treated, are too permeable to allow of plastering directly

Fig. 143. CONCRETE BLOCK ARCHITECTURE.

on the interior surface, thus making furring and lathing necessary for the plaster. The same practice should generally be followed with concrete block buildings. The popularity and usefulness of this class of construction would be greatly increased if blocks could be made sufficiently waterproof to allow plastering directly on the interior surface.

POROUS BLOCKS.—An absolutely waterproof block, however, is not wise because it has a tendency to sweat from condensation of moisture. Walls should be slightly porous so that any moisture formed on them may be gradually absorbed and later evaporated. With this point in view, blocks should be so made that their absorption of water will be slow. For this purpose a good mixture of sand and gravel will give fairly impermeable concrete in mixtures up to 1 cement to 4 sand and gravel, but when larger proportions of sand and gravel are used, the blocks will be found quite absorbent. In order to make a block as impermeable as possible the voids must be filled with some material. This work is sometimes done by using an extra amount of cement, which, however, is an expensive method and gives stronger concrete than needed. The same results can be somewhat more cheaply accomplished by substituting a small percentage of slaked lime for a part of the cement.

SLAKED LIME.—A specially prepared article called hydrate of lime, is the most convenient material but its cost is high and carefully slaked lime is more often employed. Sometimes, an impervious layer is placed near the face or through the center of a block and with so called two piece systems the rapid penetration of moisture through a wall is prevented by leaving an air space between the two faces of the block. Special waterproofing compounds are also employed and occasionally paints and other surface coatings have been employed with more or less success. Such coatings, however, should be composed of materials which are not affected by certain chemicals in the cement. The primary condition for securing high impermeability is the use of a sufficiently wet concrete.

BEST CEMENT.—The selection of a proper cement for use in concrete block manufacture is of the utmost importance. Twenty years of constant use has demonstrated that Dragon Portland Cement is unequalled for the manufacture of concrete blocks. The concrete block maker will probably be more interested in the color of his blocks and their uniformity in this respect than in any other one of their properties. Uniformity can only be secured by the use of a cement of uniform color mixed with sand of uniform color, quantity and quality, and combined with a uniform amount of water.

Fig. 143 shows an excellent example of concrete block architecture applied to residence construction. Note the solid concrete work around the entrance, for the porch, the chimney and the foundations. The whole is very effective.

CEMENT PIPE.

NEARLY every farmer and almost every suburbanite is at one time or other interested in the drainage of some low or wet tract on part of his property. Terra cotta tile has been so extensively employed that its use is familiar to all. In many parts of the country of late, it has been possible to purchase cement pipe adapted to exactly the same uses at less money than is charged for the terra cotta tile. Any farmer or owner of an estate whose land needs much draining can manufacture his own cement pipe more cheaply than he can purchase it.

There are to be purchased on the market, metal molds for making cement pipe and with one or two such molds, a supply of sand and cement, and a protected floor where the fresh pipes can be set to harden and where they can be sprinkled twice a day, the progressive farmer or owner of a country estate can supply himself at exceedingly small cost with enough pipe to take care of all his needs.

The cement and sand should be mixed very thoroughly with so much water that when the mortar is tamped into the molds it will be just dry enough to remain intact when the molds are removed.

A large number of bottom boards must be supplied because the pipe should not be removed for at least a week after being molded. The pipe resting on the boards should be carefully set aside and daily wet as described in connection with the chapter on concrete blocks, page 180.

A tight mixing platform should be provided for preparing the mortar and tamping the molds. The method to be used in mixing is found in the chapter on "Mixing Concrete by Hand."

The following are the sizes in which pipe should be made: All dimensions are in inches.

Inside Diameter	Thickness	Length	Inside Diameter	Thickness	Length
4	3/4	18	15	1 5/8	24
5	1	18	18	1 3/4	24
6	1	18	20	1 3/4	24
8	1	18	24	2	24
9	1 3/8	18	26	2	24
10	1 3/8	24	30	2 1/2	24
12	1 1/2	24	36	3	24

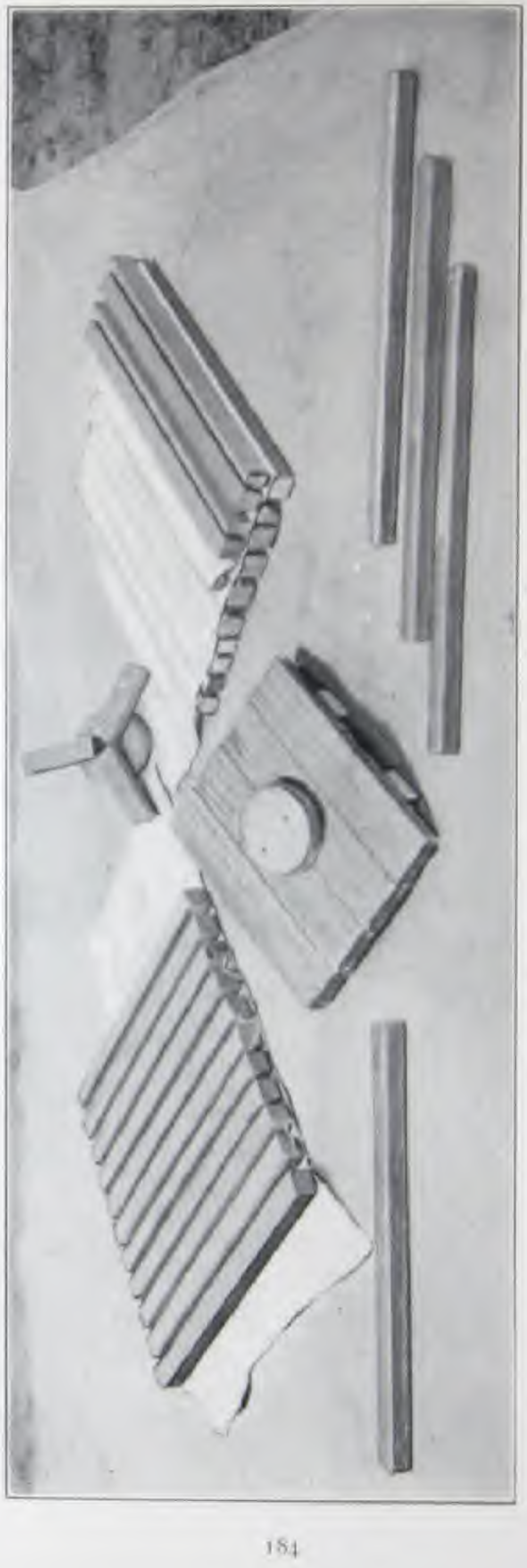


Fig. 144. HOME MADE FORMS FOR MAKING CEMENT PIPE.

A 1:3 mixture is best, although 1:4 is sometimes found sufficiently rich. One cubic yard of sand will make approximately the following numbers of pipes, each cubic yard of sand requiring 9 bags of cement. These quantities are for straight pipe, not for pipe molded with bells and spigots.

Diameter	Number	Diameter	Number
4"	233	16"	21
5"	137	18"	18
6"	118	20"	16
8"	91	24"	12
9"	63	26"	10
10"	39	30"	7
12"	30	36"	5
15"	23		

FORMS.—A good carpenter can build wooden forms if a job is too small to warrant the purchase of metal molds. It is first necessary to make as many pallets as the number of pipes which will be made in a week. These are simply squares of 7/8 inch tongued and grooved material fastened together with two cleats of the same material. They should be about six inches larger than the diameter of the pipe to be made and the cleats should not be nailed close to the edges, but sc that it is easy to get one's fingers under the board and pick it up. Next secure two pieces of thin sheet metal large enough to wrap entirely around the outside of a pipe of the size which it is desired to make. If this thin sheet metal is not obtainable, secure two pieces of canvas or its equivalent. Burlap, grain bags, oil cloth, or carpet is all right if strong. Also secure a box of ordinary carpet tacks if canvas is to be employed. Cut a number of sticks of wood about one inch square and 18 or 24 inches long, according to the size of pipes which are to be made. Lay the sticks parallel with one another and a small distance apart and tack the canvas tightly to each end of each stick. This will make it possible to roll up the canvas either side out just the size of the pipes unless the sticks have been placed too close together. One or two experiments will show how far apart the sticks must be in order to get the roll just the size of the inside of the pipe when the canvas is on the outside. Leave one stick loose at the end of the strip for the inside form. The sticks can be close together for the piece which is to form the outside, because the canvas will then be on the inside of the form. A flap of three or four inches of canvas should be left on one end and just enough sticks used to fit around the inside and outside respectively of the proposed pipe.

Next cut out some wooden discs of a diameter less than the inside diameter of the pipe by twice the thickness of the sticks and canvas. Nail these to the centres of the pallets. Cut an extra disc and nail on one side three little projecting blocks like fingers, which will extend over the edge about one inch at points around the disc.

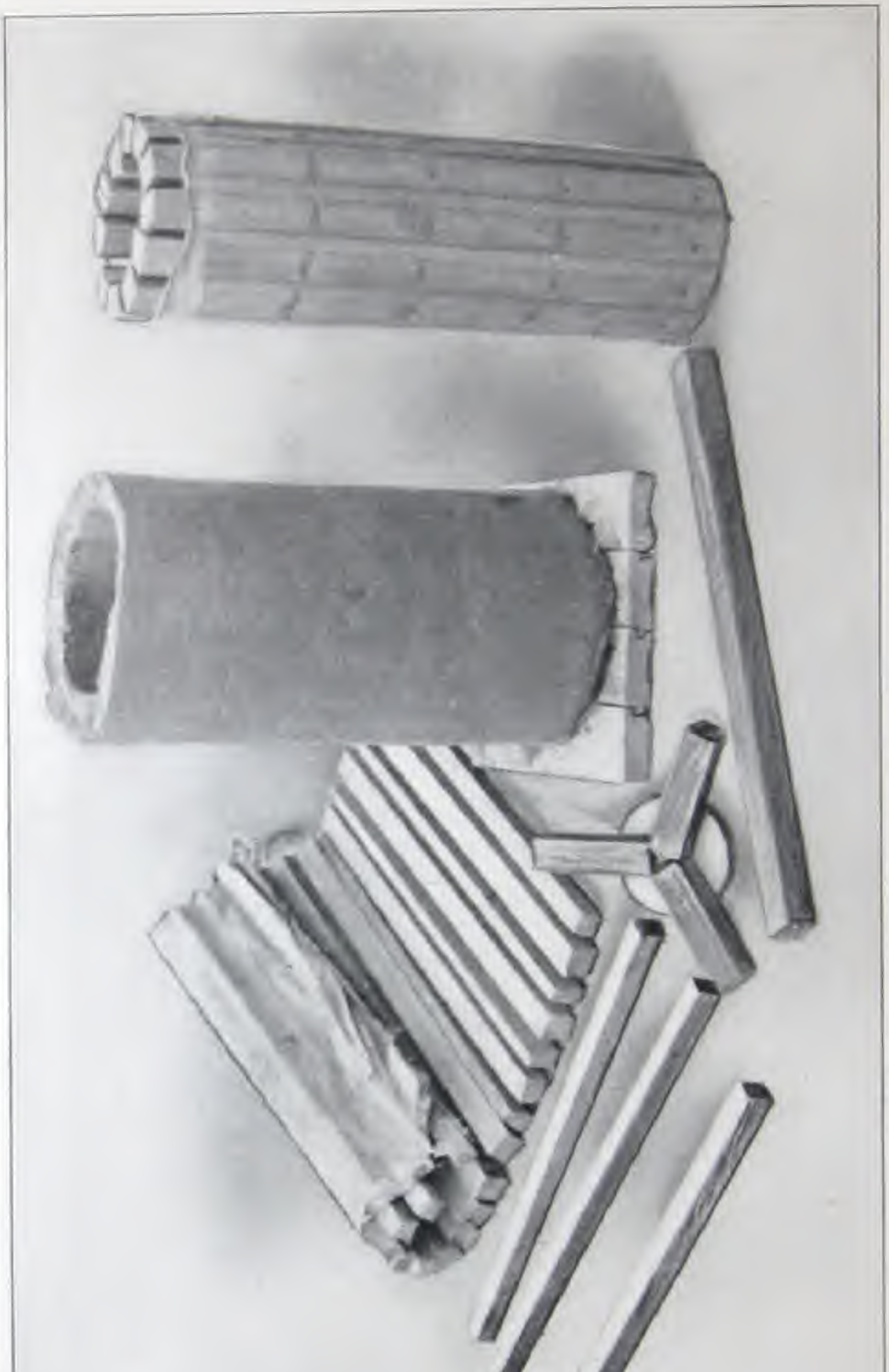


Fig. 145. CEMENT PIPE AND FORMS WITH WHICH IT WAS MADE.

Stand the small roll on one of the pallets with the canvas turned outside and place the disc with the projections inside the upper end with the projections resting on the ends of the sticks. Put in place the loose stick with the others. This should make a good cylinder just the size of the inside of the pipe.

Cut three square sticks 30 inches long and of a thickness equal to that of the pipe to be built. Stand these against the inside cylinder and then wrap them loosely with the other piece of canvas turning the sticks to the outside.

Two or three turns of wire are then to be wrapped around the mold near the top and near the bottom and tightened up by means of a stick just as has been described for octagonal column forms. This tightening should not be carried to such an extent that the spacing sticks cannot be moved readily up and down between the two forms.

Cement mortar mixed as above described, is then to be deposited between the forms and tamped thoroughly in place by means of the spacing sticks.

As soon as it is possible to remove the forms, they can be employed for the manufacture of another pipe, and since it is possible so to proportion the amount of water in the mix as to produce a pipe of such consistency that the forms can be removed within a few moments, a continuous operation is possible. Forms manufactured as described above have actually been used for the making of cement pipe with entire success. They are shown in Fig. 144 and a pipe made with them is represented in Fig. 145.

TREE DENTISTRY.

PRESERVE your old orchard and shade trees. Trees are almost a necessity of modern life and their neglect has been a crying shame in this country for many years. With the advent of Portland Cement a new art in connection with the science of orchardry and forestry has developed, namely that of "tree dentistry" so called.

Trees suffer damage by winds, heavy snows, boring insects and animals, and the insiduous effects of decay. Limbs of trees are often split by violent winds and heavy snow, water enters the crevices and decay almost immediately follows, enlarging the cavity until finally another storm produces the ultimate destruction of the one-time giant of the forest. Nature uses every effort to correct this ruin and by the practical attention of a skilled forester, many trees in imminent peril can be completely saved and given a prolonged length of life. Nature assists, but cement and surgery are necessary preliminaries. It is first needful to correct the tendency to split (if such has been the cause of the trouble), but by proper installation of chains, any further trouble of this sort can be obviated. It is next essential that every particle of decayed material be removed from the interior of a rotting trunk. See Fig. 146. Then, a steel brace may be required to strengthen the tree and re-establish the stability of which decay has robbed it. The interior of the cavity should first be coated with a waterproof compound and then should be studded with nails or similar devices to afford a close bond between the filling and the firm wood, and further reinforcement in the form of bars, wires or wire mesh should be carefully installed to reinforce the concrete to be used for filling. This is shown in Fig. 147. The cement is plastered in a very moist condition and carefully built out into the original outline of the tree. See Fig. 148. This work must be made particularly dense so as to exclude all water, since otherwise the filling is worse than useless. No porous or undrained spot should be allowed. Even after the cavity has been filled with cement, unless the work is carefully done, the swaying of the tree in the winter will be apt to separate the cement from the wood so that a narrow crevice is formed, into which moisture can penetrate and the decay continue even worse than before. Expert workmen, therefore, prepare special "water chutes," or deep grooves just around and within the opening, so as to let out to the ground all incoming moisture.

Figure 146.

BEFORE TREATMENT

Figure 147.

METHOD OF TREATMENT

SAVING THE TREES

Figure 148.

LARGE CAVITY FILLED

Figure 149.

YEARS AFTER TREATMENT

COURTESY OF DAVEY TREE EXPERT CO.

The bark has to be carefully cut back for an inch or so in order to prevent bruising it while the work is in progress, but it can be replaced and will eventually cover the wound in the side of the tree through nature's agencies, as shown in Fig. 149. If properly replaced, the tree will thus regain its normal appearance, the outside bark completely surrounding the concrete filling of a one time deadly cavity. Where cavities are of an exceptional size, a form consisting of strips of metal is first used, and the cement is forced down into every crevice and allowed to set. This form is afterwards removed and a coat of surface finish applied. In this way the forester is enabled to build out trees where fully one half the wood may have been destroyed by lightning or other causes. The cement filling may be finally painted the same color as the bark of the tree so that the original defect is entirely unnoticeable.

Since only the highest quality of cement should be used in this form of treatment, "Dragon" cement has proved to be essential for the preservation of the beauty and life of many trees otherwise ruined.

Dragon
PORTLAND CEMENT

Partial List of Uses of Portland Cement

A.

Abattoirs
Abutments
Air Tanks
Amphitheatres
Anchorages
Aquariums
Aqueducts
Arches
Armor for Battleships
Art Figures
Ash Pits
Assay Furnace Lining
Arbor Posts

B.

Ballast Tanks in Warships
Ballustrades
Band Stands
Barrels
Base Boards
Bath Tubs
Beams
Bedding Tile Ducts
Benches
Bicycle Race Tracks
Bicycle Paths
Bins
Blacksmith Forges
Boats
Boiler Covering
Boiling Tanks
Breakwaters
Bridges
Brine Tanks
Building Blocks
Burial Vaults
Butts for Telegraph Poles
Bumpers (car)
Bungalows
Burglar Proof Vaults

C.

Caissons
Canal Locks
Capitals
Cast Stone
Cement Brick
Cement Coal
Cementine Curtains
Cement Storage Bins
Chimneys
Chimney Caps
Churches
Cisterns
Clothes Posts
Coal Handling Plants
Coal Mines
Coal Pockets
Coal Trestles
Coffin Boxes
Columns
Coping
Cornices
Corner Stones
Crossings
Culverts
Curbing

D.

Dams
Dog Kennels
Domes
Drain Pipe
Driveways
Drip Boards for Tanks
Dry Docks
Dwellings

E.

Election Booths
Electric Conduits
Engine Beds

Pillars
Pipe
Pipe Covering
Pits, Ash
Pits, Elevator
Pits, Waterproof
Plugs for Unused Ducts
Plumbobs
Pointing Masonry
Poles, Flag
Poles, Telegraph
Poles, Trolley
Porch Blocks
Porch Columns
Porticos
Posts
Power Houses
Prison Cells
Prisons
Puddling

R.

Railbeds
Railroad Ties
Railway Stations
Reinforced Concrete
Repairing Boilers
Repairing Cracked Steam Head in Dinky Locomotives
Repairing Leaky Auto Radiators
Repairing Refrigerators
Repairing Masonry
Repairing Trees
Reservoirs
Retaining Walls
Rifle Pits
Rifle Targets
Round Houses
Roofs (reinforced)
Roofing Slabs
Roofing Tile

S.

Safes
Salt Mines
Sand Bins
Schools
Scouring, in place of Sand Soap
Sea Walls
Sewage Disposal Plants
Sewers
Sewer Pipe
Shelves
Shingles
Ships
Sidewalks
Signal Towers
Sills
Silos
Slaughter Houses
Sockets Between Joints
Spandrels
Stables
Stacks
Stack Linings
Stadium
Stairways
Stations (R. R., etc.)
Statuary
Stepping Blocks
Steps
Stock Yards
Stoves (concrete)
Street Paving
Stringers
Stringers for Steel Rails
Stucco
Subways
Surfacing Roads
Sun Dials
Survey Stakes
Swimming Pools
Switch Boards

T.

Table Tops
Tanks
Tanks, Air
Tanks, Boiling
Tanks, Brine
Tanks, Gas
Tanks, Oil
Tanks, Water
Tannery Vats
Tennis Courts
Timbering Mines
Tombs
Towers
Toy Building Blocks
Transfer-Pits
Trestles
Tunnels
Turntables
Tree Cavities

U.

Urns

V.

Vats
Viaducts
Vine Props

W

Wall Plaster
Warehouses
Warship Lining
Wash Tubs
Waterproof Pits
Water Towers
Water Troughs
Wharves
Window Sills

DRAGON
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PORTLAND
LAWRENCE PORTLAND
SIEGFRIED PA
CEMENT COMPANY
CEMENT


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CEMENT